Children's health and the environment
WHO training package for the health sector

PESTICIDES

TRAINING FOR HEALTH CARE PROVIDERS
SECOND EDITION

World Health Organization

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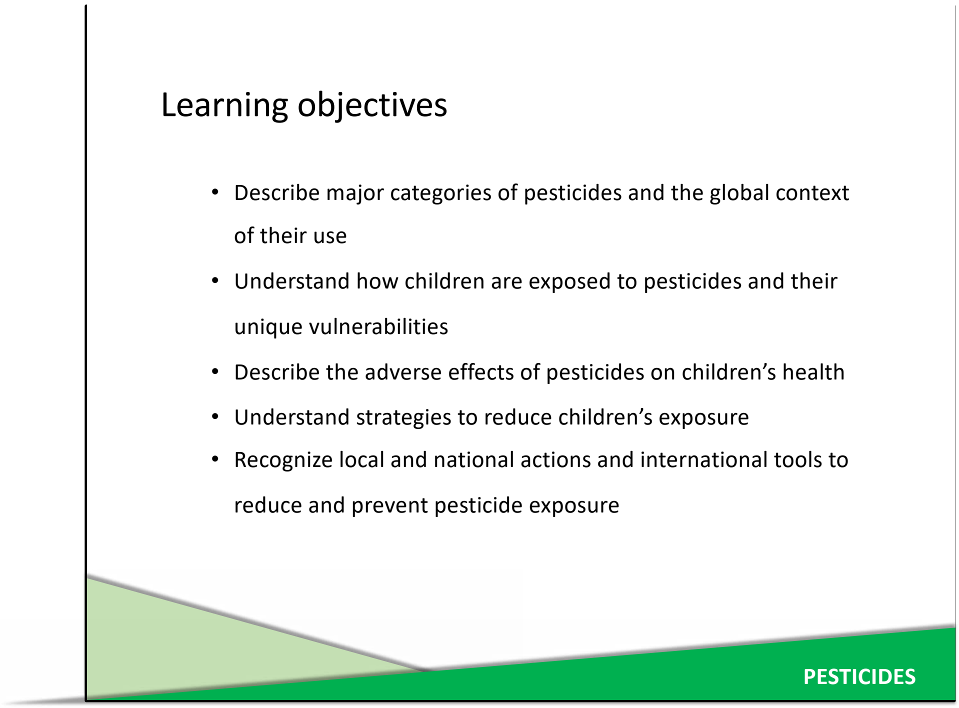
- ***Pesticides*** is one module from a larger training package focused on children's environmental health. Throughout ***Pesticides***, a number of different modules are suggested that contain additional relevant information. Consult these other modules where relevant. To see the full package visit: https://www.who.int/teams/environment-climate-change-and-health/settings-populations/children/capacity-building/training-modules;

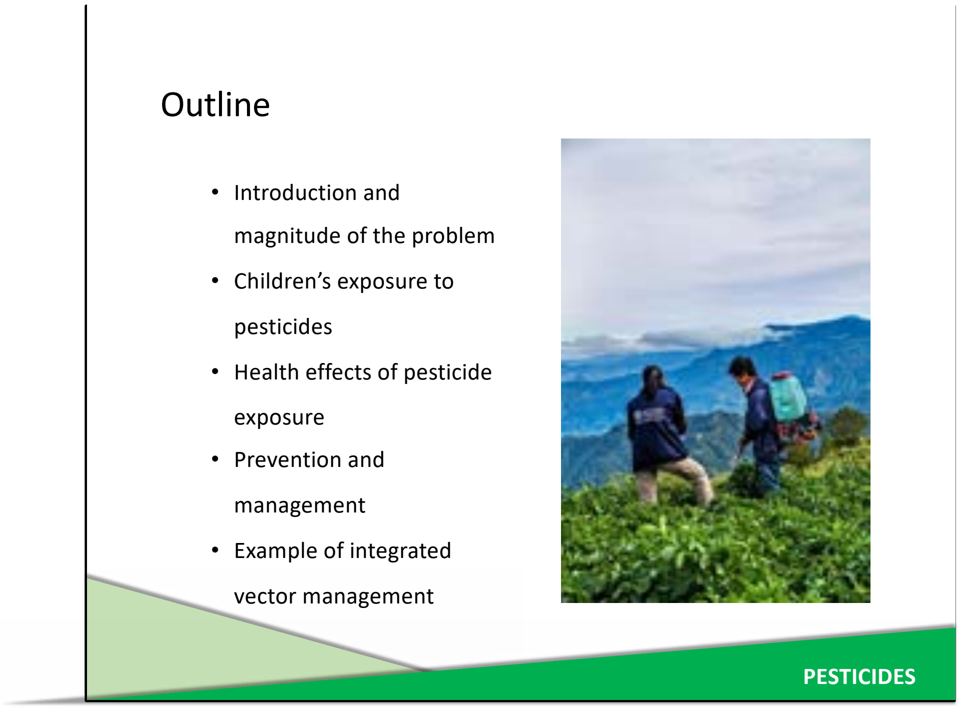
- the World Health Organization (WHO) reference number for the module ***Pesticides: training for health care providers, second edition*** is WHO/HEP/ECH/CHE/24.04;

- for more information on WHO's work on children's environmental health, please visit: https://www.who.int/health-topics/children-environmental-health.



This module gives an overview of pesticides and their potential impact on children's health. It covers many pesticides, some of which will be specifically discussed as examples throughout the module. By the end of this presentation, learners should be able to:

- describe major categories of pesticides and the global context of their use;
- understand how children are exposed to pesticides and their unique vulnerabilities;
- describe the adverse effects of pesticides on children's health;
- understand and suggest individual-level strategies to reduce children's exposure to pesticides;
- recognize useful local and national actions and international tools to reduce and prevent pesticide exposure.



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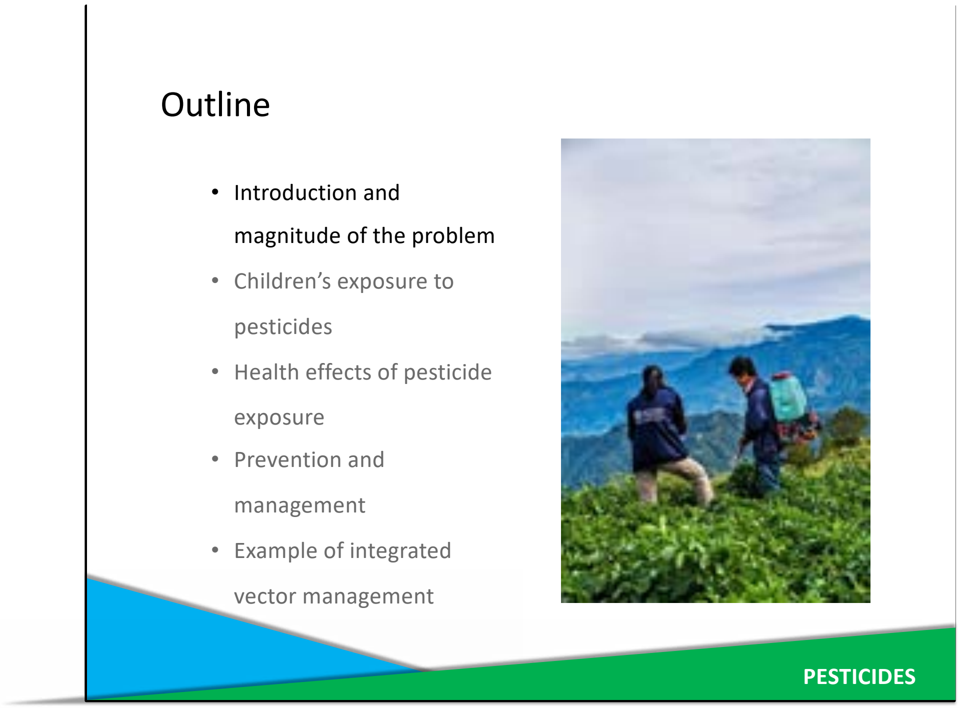
This training module includes the following sections:
- introduction to pesticides and the magnitude of the problem;
- children's exposure to pesticides in the environment;
- health effects of pesticide exposure;
- prevention and management;
- an example of integrated vector management.

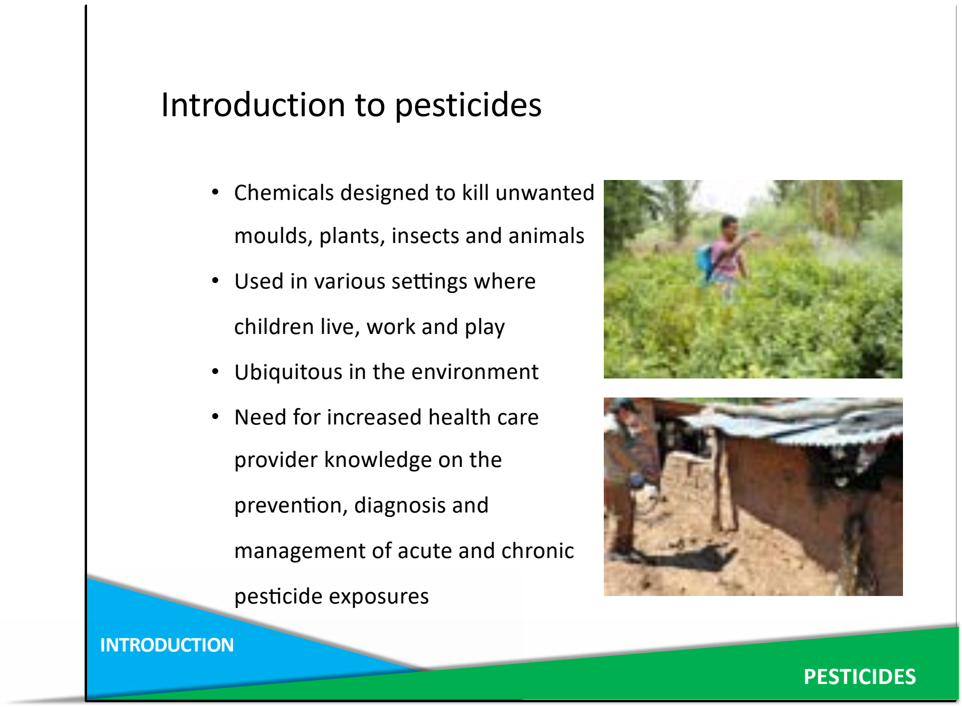
Photo:
- © WHO/ Yoshi Shimizu. A farmer spraying pesticides with WHO staff.



This module begins with an introduction to pesticides and the global magnitude of the problem.

Photo:

- © WHO/ Yoshi Shimizu. A farmer spraying pesticides with WHO staff.



Pesticides are chemical products made to kill unwanted pests, such as moulds, plants, insects and rodents *(1)*. Pesticides are used to protect people, crops, land, trees and property in agriculture, homes, yards, gardens, community areas and schools. They are one of the few classes of chemical products with the potential for toxic effects that are deliberately applied to the places where children live, work and play *(2,3)*. Due to their widespread use, pesticides are ubiquitous in our environment, including the air, soil, food and water *(2)*.

Since the second half of the twentieth century, production of synthetic organic chemicals has significantly increased *(4)*. For decades, the impacts of synthetic pesticides on children's health and the environment went largely unchecked. Scientific research has now developed an understanding of the broad range of adverse health effects in children that are associated with pesticides. Importantly, chemicals used in pesticide products have mechanisms of toxicity that often target the same biological systems in both pests and humans. There is also a well-defined gap in the training of health care providers on the prevention, diagnosis and management of acute and chronic pesticide exposures *(5)*. This module aims to help close this gap, emphasizing the need to globally reduce exposure to pesticides and protect children's health and futures.

References:

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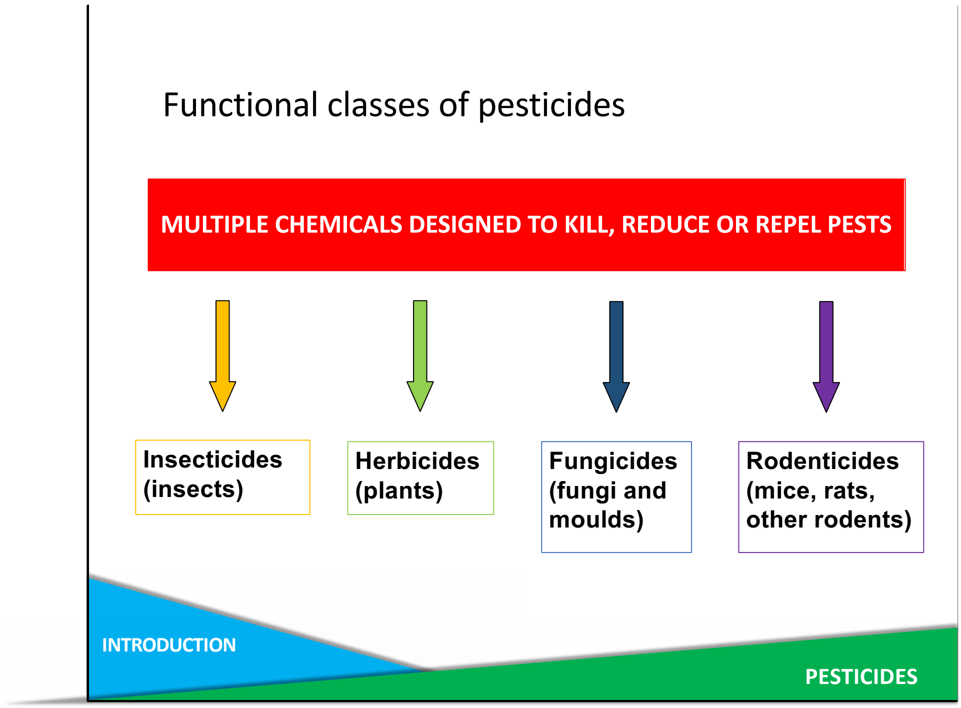
5. Roberts JR, Karr CJ, Council On Environmental Health. Pesticide exposure in children. Pediatrics. 2012:130(6):e1765–88.

Photo:

- Top: © WHO/ Angeliki Antonia Balayannis. Removing access to means of suicide is an effective method of prevention. In a WHO study in two villages in India, a year after the introduction of a central storage system for pesticides, the number of suicides had decreased.
- Bottom: © WHO/ Fernando G. Revilla. Mud hut walls being sprayed with insecticide to kill triatomine bugs that transmit Chagas disease.



Pesticides are classified based on the pests they target. Well-known functional classes of pesticides include *(1,2)*:

- insecticides, which target insects such as mosquitoes and locusts;
- herbicides, which target plants including weeds or other undesirable plants;
- fungicides, which target fungi and moulds;
- rodenticides, which target various rodent species, such as rats and mice.

There are also many other chemical classes that are designed to kill, reduce or repel unwanted organisms and are used in various settings where children live, work and play. Some of the same chemicals used in pesticides may also be used for public health purposes such as antimicrobial agents, disinfection and sanitization. Another public health use of pesticides is the control of vectors of disease, such as mosquitoes *(1)*.

The following slides will review in more detail the chemical classes of insecticides and herbicides.

References:

1. Ingredients used in pesticide products: types of pesticide ingredients [website]. Washington (DC): United States Environmental Protection Agency; 2023 (https://www.epa.gov/ingredients-used-pesticide-products/types- pesticide-ingredients, accessed 11 January 2024).
2. The WHO recommended classification of pesticides by hazard and guidelines to classification, 2019 edition. Geneva: World Health Organization; 2021 (https://iris.who.int/handle/10665/332193, accessed 11 January 2024).

Insecticides organized by chemical class

CHEMICAL CLASS	NOTES	EXAMPLES
ORGANOPHOSPHATES	Major source of acute pesticide poisonings	Chlorpyrifos Malathion
ORGANOCHLORINES	Persistent organic pollutants Many banned under Stockholm Convention	DDT
CARBAMATES	Similar structure and mechanism of action as organophosphate insecticides	Aldicarb Carbaryl
PYRETHROIDS	Increasingly used in some countries in residential and agricultural settings to replace organophosphates and organochlorines	Permethrin Deltamethrin
NEONICOTINOIDS	Increasing use Persistent in environment Threat to pollinators	Imidacloprid

Source: (1–10). DDT, dichlorodiphenyltrichloroethane.

INTRODUCTION

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Health care providers should be familiar with the major chemical classes of insecticides. Insecticides target insects such as mosquitos and locusts. Insecticides generally act on four major nerve targets, which are shared by children *(1)*. For example, some insecticides inhibit acetylcholinesterase, an enzyme which works at nerve cell junctions in the central and peripheral nervous system and is essential for normal nervous system function *(2)*. The table on this slide highlights five of the major chemical classes of insecticides, including some notes about each and some common examples.

1. **Organophosphates** are a well-known class of insecticide and a major source of acute pesticide poisonings in children and adults *(3)*. For example, a target of organophosphate insecticides is acetylcholinesterase. Inhibition of acetylcholinesterase leads to cholinergic syndrome *(1)*. Organophosphates have been evaluated extensively for their adverse effects on children's neurodevelopment *(4).* Common examples of organophosphates include chlorpyrifos and malathion. Some organophosphate pesticides are banned in some countries, or their use is strictly regulated. For example, in 2022 the United States Environmental Protection Agency announced its intention to ban the use of chlorpyrifos on food and agricultural products *(5)*. Chlorpyrifos is banned for sale and use in member states of the European Union *(6)*.

2. **Organochlorines** are persistent organic pollutants (POPs), and many are banned under the Stockholm Convention on Persistent Organic Pollutants *(7)*. Dichlorodiphenyltrichloroethane (DDT) is one of the most well-known organochlorines. DDT was used widely during the Second World War to protect people from malaria and other vector-borne diseases. Following the Second World War, it was used in agricultural practices, especially cotton farming. After the publication of the influential book *Silent Spring* by Rachel Carson in 1962, which described the toxic effects that DDT was having on the eggs of pelagic birds, DDT was banned in the United States of America in 1972. In 2001, it was restricted under the Stockholm Convention for all uses with the exception of vector control in malaria-endemic countries where no locally safe, affordable or effective alternative is available *(7–9)*. DDT must be used in strict accordance with World Health Organization's (WHO) recommendations and guidelines. WHO supports the reduction and eventual elimination of the use of DDT, while minimizing the burden of vector-borne diseases *(10)*. Despite bans in many countries, decreasing use in malaria-endemic countries and declines evident from environmental monitoring programmes, DDT persists in the environment today due to its long half-life and mobility. DDT is still detected in food and breastmilk *(7,10)*.

3. **Carbamates** are another major class of insecticides that have a similar structure and mechanism of action as organophosphate insecticides. Aldicarb is the most toxic carbamate and is used on food crops. Another common carbamate pesticide is carbaryl, which is found in widely-used household and domestic insecticides *(3)*.

4. **Pyrethroids** are the fourth major class of insecticides listed in the table. Pyrethroids are increasingly used in some countries in residential and agriculture settings to replace previously used organophosphate and organochlorine insecticides *(11)*. They are applied to crops, gardens, pets, and directly to people *(12)*. Common examples include permethrin, found in treatment shampoos for head lice, and deltamethrin, a broad-spectrum insecticide used in many agricultural, domestic and public health interventions including insecticide-treated nets *(3,10)*.

5. **Neonicotinoids** are the final major class of insecticides listed in this table. They are increasingly used in agricultural settings and are also used as flea control for pets. Neonicotinoids are persistent in the environment and are a threat to pollinators, especially bees. The most common chemical in this class is imidacloprid, which is used to protect against many sucking insects, including fleas and common garden pests such as aphids *(3,13)*.

Note: use the latest Pesticide Action Network (PAN) International list of banned pesticides to discuss any banned insecticides in your country. If malaria is endemic in your country, discuss if DDT is used as a vector control measure and the circumstance under which it is allowed to be applied. To download the list visit: https://paninternational.org/pan-international-consolidated-list-of-banned-pesticides/.

References:

1. Casida JE. Pest toxicology: the primary mechanisms of pesticide action. Cheml Res Toxicol. 2009;22(4):609–19.
2. Lionetto MG, Caricato R, Calisi A, Giordano ME, Schettino T. Acetylcholinesterase as a biomarker in environmental and occupational medicine: new insights and future perspectives. Biomed Res Int. 2013;2013:321213.
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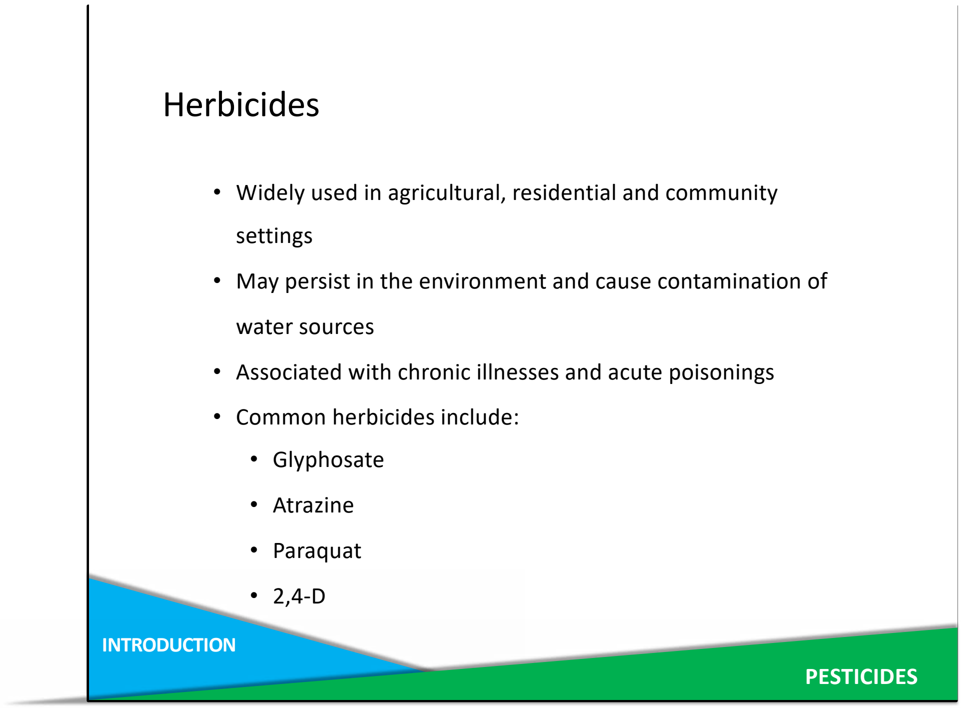
13. Simon-Delso N, Amaral-Rogers V, Belzunces LP, Bonmatin JM, Chagnon M, Downs C et al. Systemic insecticides (neonicotinoids and fipronil): trends, uses, mode of action and metabolites. Environ Sci Pollut Res Int. 2015;22(1):5–34.



Herbicides kill unwanted plants. They are used in agricultural, residential, school and community settings where children and adolescents live, work and play *(1)*. Herbicides are generally designed to kill using plant-specific pathways that are essential in plants, but not mammals *(2)*. They can, however, still cause harm to humans at the cellular level *(3)*. The International Agency for Research on Cancer (IARC) has classified some commonly used herbicides as possibly or probably carcinogenic to humans *(3,4)*. For example, glyphosate, the active ingredient in many commonly used herbicides, such as Roundup, was classified by IARC in 2015 as a Group 2A carcinogen – probably carcinogenic to humans *(4)*.

Herbicides are used widely in agricultural practices and can contaminate farmlands and water sources, including freshwater *(5)* and drinking water *(6,7)*. For instance, atrazine, banned as of May 2022 in 44 countries *(8)*, is still used widely in many countries around the world including Brazil, India and the United States of America *(9)*. In residential settings, parks, schools and other community settings, herbicides such as glyphosate are often used for cosmetic purposes to destroy unwanted plants, many of which pose no threat to humans *(10)*.

Herbicides can be acutely toxic. For example, a small amount of ingested paraquat can quickly lead to death *(11)*. According to the most recent Pesticide Action Network (PAN) International report, paraquat is banned in 58 countries. Globally, however, it is still a commonly used herbicide *(8,11)*. 2,4-dichlorophenoxyacetic acid (2,4-D) is another widely used herbicide that targets broadleaf weeds and is applied in many settings including domestic and agricultural contexts. The use of 2,4-D is expected to increase worldwide *(12,13)*.

Note: use the latest PAN International list of banned pesticides to discuss if any of these herbicides are banned in your country. To download the list visit: https://pan-international.org/pan-international-consolidated-list-of-banned-pesticides/.

References:
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Some common classes of herbicides and rodenticides

CHEMICAL CLASS	NOTES	EXAMPLES
ORGANOPHOSPHATE HERBICIDES	Some of the most widely used weed killers in the world, including in agriculture practices and domestic gardens and lawns	Glyphosate
PHENOXYACETIC ACIDS	Widely used herbicides, includes 2,4,5-T which is now restricted under the Rotterdam Convention	2,4-D
BIPYRIDYL HERBICIDES	Rapid acting, non-selective herbicides Extremely high case fatality rate when ingested	Paraquat
WARFARIN AND RELATED RODENTICIDES	Inappropriate use in domestic settings is a common cause of acute poisoning in children due to ingestion	Brodifacoum

Source: *(1–8)*. 2,4-D, 2,4-dichlorophenoxyacetic acid; 2,4,5-T, 2,4,5-trichlorophenoxyacetic.

INTRODUCTION

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Health care providers should be familiar with the major chemical classes of herbicides and rodenticides. Herbicides are some of the most common pesticides used in domestic settings and are some of the leading causes of acute poisonings in children due to unintentional ingestion. The table on this slide highlights three major chemical classes of herbicides and one major chemical class of rodenticide, including some notes about each and some common examples.

1. **Organophosphate herbicides** include a wide variety of herbicides that are used broadly in agricultural and domestic settings. Glyphosate is a non-selective herbicide and is one of the most widely used pesticides in the world. In agricultural settings, glyphosate formulations are largely used on genetically modified crops (i.e., glyphosate-resistant). The widespread and significant use of glyphosate has become a focus of public health concern, particularly high occupational or environmental exposures and possible chronic health outcomes. Research has reported possible associations between exposure to glyphosate and adverse effects on developmental, endocrine, renal, hepatic, haematological and reproductive outcomes *(1)*. The International Agency for Research on Cancer (IARC) has classified glyphosate as a Group 2A carcinogen – probably carcinogenic to humans *(2)*. It is important to note that organophosphate herbicides have different mechanisms of action than organophosphate insecticides and consequently have different health effects in children.

2. **Phenoxyacetic acids** are an important chemical class of herbicide due to their wide-spread use in agricultural and public settings, such as public parks. This class includes 2,4,5-trichlorophenoxyacetic (2,4,5-T), which is now restricted under the Rotterdam Convention *(3).* 2,4-dichlorophenoxyacetic acid (2,4-D) is another common phenoxyacetic herbicide. Recent biomonitoring programmes conducted in the United States of America have found increasing exposure levels to 2,4-D in the general population due to their increasing use in the agricultural industry. Children have been shown to have higher urinary biomarkers of exposure to 2,4-D compared to non-occupationally-exposure adults *(4)*. There is limited research investigating the long-term health effects of 2,4-D. IARC has classified 2,4-D as a Group 2B carcinogen – possibly carcinogenic to humans *(5)*.

3. **Bipyridyl herbicides** are rapid acting, nonselective and toxic to a wide variety of grasses and weeds. Paraquat falls under this class of herbicide. Paraquat has been recognized as one of the most toxic herbicides and has a very high fatality rate when ingested. The main concern for children and adolescents is unintentional ingestion, however, in some areas of the world, paraquat is a leading cause of intentional poisoning and suicide *(6)*. A review published in 2021 indicated that children living in rural areas are at higher risk of paraquat poisoning compared to children living in urban areas, and unintentional poisoning due to paraquat ingestion had a mortality rate of 19% in children *(7)*.

4. **Warfarin and related rodenticides** are anticoagulants. Ingestion by children is a common cause of calls to poisons centres for acute pesticide exposure. These rodenticides come in small granular and pellet formulations that are often brightly coloured and within reach of children, for example placed on the floor or under cupboards. The primary health effect is anticoagulation, usually occurring after a latency period 24–48 hours *(8)*.

Note: use the latest Pesticide Action Network (PAN) International list of banned pesticides to discuss any banned herbicides in your country. To download the list visit: https://pan-international.org/pan-international-consolidated-list-of-banned-pesticides/.

References:

1. Toxicological profile for glyphosate. Atlanta: Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, Public Health Service; 2020 (https://wwwn.cdc.gov/TSP/ToxProfiles/ToxProfiles.aspx?id=1488&tid=293, accessed 11 January 2024).
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Pesticide composition and formulations

- **Active ingredient(s)**: control target organism(s)
- **Inactive ingredients (co-formulants)**: added to improve application, function and longevity
- Formulations are generally proprietary
- Inactive ingredients and formulations can be more toxic than active ingredients

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Pesticides are made as formulations that contain both active and inactive (co-formulants) ingredients *(1)*. The **active ingredient** is used to control target organisms and is generally the focus of the most rigorous toxicological regulatory tests performed on mammals *(1,2)*. Inactive ingredients, sometimes referred to as co-formulants or inert ingredients, are chemicals added to pesticide formulations to improve their application, function and longevity *(1)*. Because inactive ingredients are often considered proprietary information, they may not be listed, or required to be listed, on product labels *(2,3)*. The photo on the slide shows the label of a broad-spectrum, domestic insecticide listing only the active ingredient (deltamethrin).

Both active and inactive ingredients, as well as their combination in proprietary formulations, can be hazardous to human health. Some 'inactive ingredients' may be more toxic than their 'active' counterparts. Toxicity of inactive ingredients is often not studied to the same degree as that of active ingredients *(4)*. Some regulators require testing and approval processes for all ingredients included in pesticide formulations, however, other regulators do not complete such testing, despite evidence indicating that pesticide formulations can more toxic than their active ingredients *(2)*.

References:
1. Ingredients used in pesticide products: basic information about pesticide ingredients [website]. Washington (DC): United States Environmental Protection Agency; 2023 (https://www.epa.gov/ingredients-used-pesticide-products/basic-information-about-pesticide-ingredients, accessed 11 January 2024).
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Photo:
- © Julia F. Gorman. Photo used with permission. Front labelling information of a common insecticide used for domestic garden applications.

This slide shows a map illustrating global pesticide use in agriculture in 2020. The green circles indicate the amount of pesticides used in each country measured in thousand tonnes.

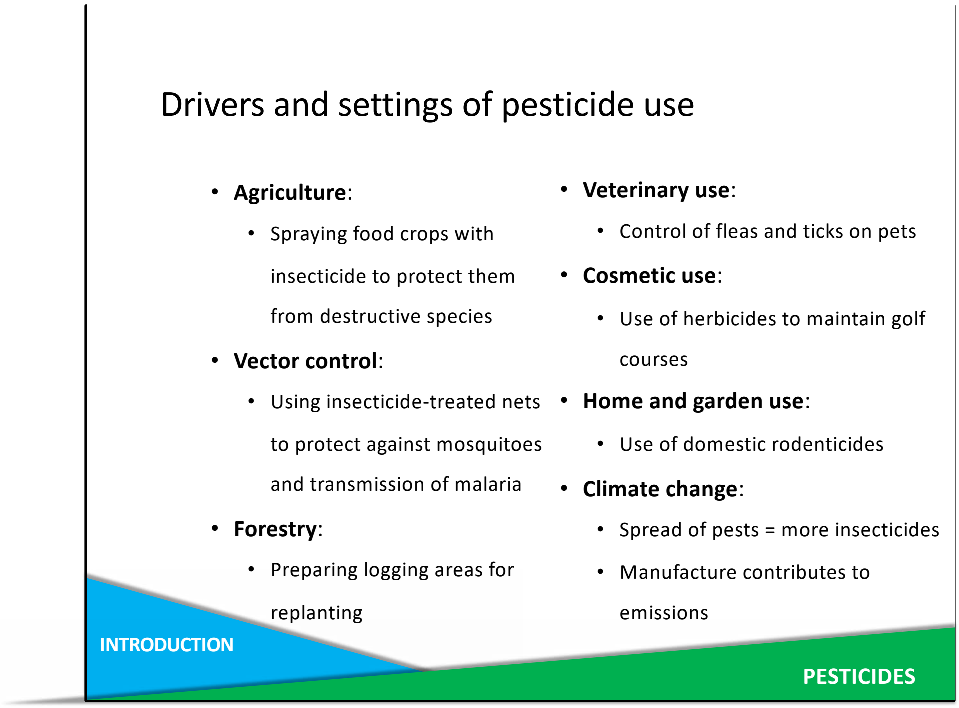
Between 2000 and 2020, total global pesticide use in agriculture increased by 30%. The majority of this increase occurred between 2000 and 2012 and has since plateaued *(1)*. In 2020, the United States of America, Brazil and China were the largest users *(1)*. In the next slide, we will review the major drivers and settings of pesticide use globally.

Note: find the annual data on pesticides in agriculture in your country by visiting: http://www.fao.org/faostat/en/#data/Rp.

References:

1. World food and agriculture: statistical yearbook 2022. Rome: Food and Agricultural Organization of the United Nations; 2022 (https://www.fao.org/documents/card/en/c/cc2211en, accessed 11 January 2024).

Map:
- © WHO.
- Data: FAO.



This slide discusses the drivers and settings of pesticide use. It highlights six major settings that are driving the use of pesticides and gives an example of each.

The agricultural industry is the most significant driver of the global production and use of pesticides. In 2018, the World Bank estimated that 85% of the pesticides used worldwide were for agricultural purposes to protect crops from moulds, bacteria, invasive plants and potentially destructive insects *(1)*. While this use contributes to increased crop yields, crop yields associated with pesticide use have not ended world hunger *(2)*. In 2022, approximately 735 million people globally, around 9.2% of the world's population, were considered undernourished *(3)*. Moreover, a significant proportion of pesticides in agricultural industry are used on non-food crops. For instance, 2018–2020 less than 15% of global production of maize and other coarse grains was used directly for food; more than half of these crops were used as feed to support the demand for meat production, which is increasing in many parts of the world *(4,5)*. Cotton is another crop heavily reliant on the use of pesticides *(6)*.

Vector control is another major global driver of pesticide use. While insecticides used for vector control are important to global public health, they can also pose a risk to human health and the environment. According to the United Nations Children's Fund (UNICEF), 600 million children, more than 1 in 4 children globally, were highly exposed to vector-borne diseases in 2021 *(7)*. Globally, malaria is the deadliest vector-borne disease *(8)*, causing an estimated 608 000 deaths in 2022 *(9)*. The World Health Organization's (WHO) African Region carried 94% of all malaria cases and 95% of all deaths in 2022; children under 5 years of age accounted for 78% of deaths in the region in 2022 *(9)*. The main method of vector control worldwide since 1940 has been the use of chemical insecticides to kill or deter vectors *(10,11)*. Methods of insecticide application to prevent vector-borne diseases include insecticide-treated nets, indoor residual spraying, space spraying, and larviciding, the application of insecticides to aquatic habitats *(11)*. These methods have had successes in malaria eradication in some countries.

The use of insecticides for vector control has been significantly affected by the development of insecticide resistance *(12)*. In 2018, malaria vector resistance had been reported in all WHO regions except the WHO European Region, which had limited monitoring *(13)*. Resistance to the four major classes of insecticides including pyrethroids, organochlorines, carbamates and organophosphates has been recorded *(13)*. WHO recommends integrated vector management to protect public health while minimizing harm to the environment and insecticide resistance. Integrated vector management optimizes the use of resources for vector control so that the processes are more efficient, cost effective, ecologically sound and sustainable *(14)* (see Slides 37 and 38 for more on integrated vector management).

Application of pesticides in forestry practices usually involves the use of herbicides to manage and control the growth and spread of unwanted vegetation. Pesticide use in forestry usually involves the use of herbicides to manage and control the growth and spread of unwanted vegetation and preparing logging areas for replanting. Pesticides may also be used to protect tree saplings from insects. Beyond forestry, there are several similar non-agricultural uses of pesticides including controlling invasive and destructive species, controlling plant growth on streets to ensure traffic visibility and controlling weed growth on railway tracks and in waterways to ensure functioning of transport *(15)*.

Pesticides are used in veterinary practices for several reasons. Domestic pets, including cats and dogs, are regularly directly treated with insecticides to control pests, including fleas and ticks. Insecticides are also used in animal husbandry to protect against pests such as flies, mites and bed bugs. They are used on many animals globally, including cattle, sheep, pigs, horses and poultry *(16)*.

Cosmetic and non-essential uses of pesticides do not reduce human disease or protect food crops but are often used to kill unwanted plants in areas such as yards, gardens and recreational areas, such as golf courses, to give the area a certain look and appeal. Some pesticide products are intended for these uses. Like all pesticides, these agents can potentially contaminate air, soil, food, drinking water and local waterways, and expose children who play on or near sprayed areas *(17)*.

Pesticides are used in homes and gardens for many purposes, such as the control unwanted insects, vectors or rodents, including rats and mice. In the United States of America, where data is available on annual active ingredient pesticide use across different sectors, significant amounts of pesticides are used in homes and gardens where children spend much of their time *(18)*.

The relationship between pesticides and climate change is complex. Pesticides can contribute to climate change as many are derivatives of fossil fuels and can release greenhouse gases when excavated *(19)*. Climate change may also increase the use of pesticides due to changes in temperature and precipitation which can drive the spread of pests *(20)*. Although the precise effect of climate change on vector-borne diseases is not certain, warmer temperatures will likely increase transmission of diseases, such as malaria, requiring increased use of pesticides for vector control *(21)*.

Note: for more information on children's health and climate change see the module ***Global climate change and child health***.

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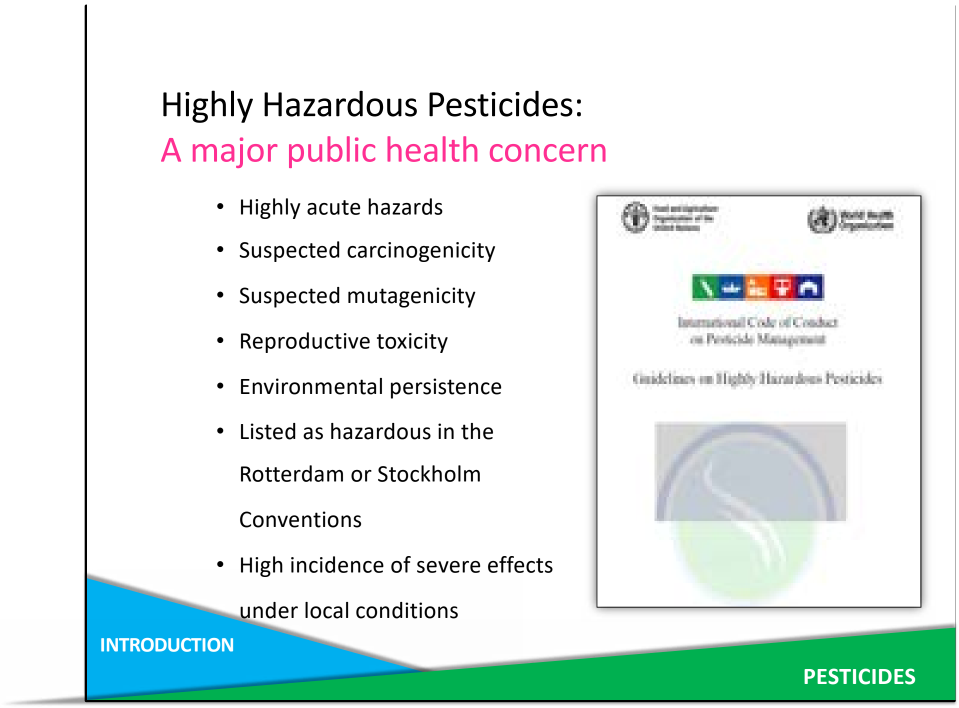

While all pesticides are inherently toxic, Highly Hazardous Pesticides (HPP) carry an increased risk of acute or chronic harm to human health and the environment *(1)*.

The Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization's (WHO) International Code of Conduct on Pesticide Management defines HHPs as those that **have one or more of the criteria listed below**: *(2)*

- classes Ia (extremely hazardous) or Ib (highly hazardous) of the WHO Recommended Classification of Pesticides by Hazard *(3)*;
- suspected carcinogenicity: Categories 1A and 1B according to the Globally Harmonized System on Classification and Labelling of Chemicals (GHS) *(4)*;
- suspected mutagenicity: Categories 1A and 1B according to the GHS *(4)*;
- reproductive toxicity: Categories 1A and 1B of the GHS *(4)*;
- listed by the Stockholm Convention on Persistent Organic Pollutants in Annexes A and B *(5);*
- listed by the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade in Annex III *(6)*;
- listed under the Montreal Protocol on Substances that Deplete the Ozone Layer *(7)*;
- pesticide products with active ingredients and formulations that have shown a high incidence of severe or irreversible adverse effects on human health or the environment.

References:

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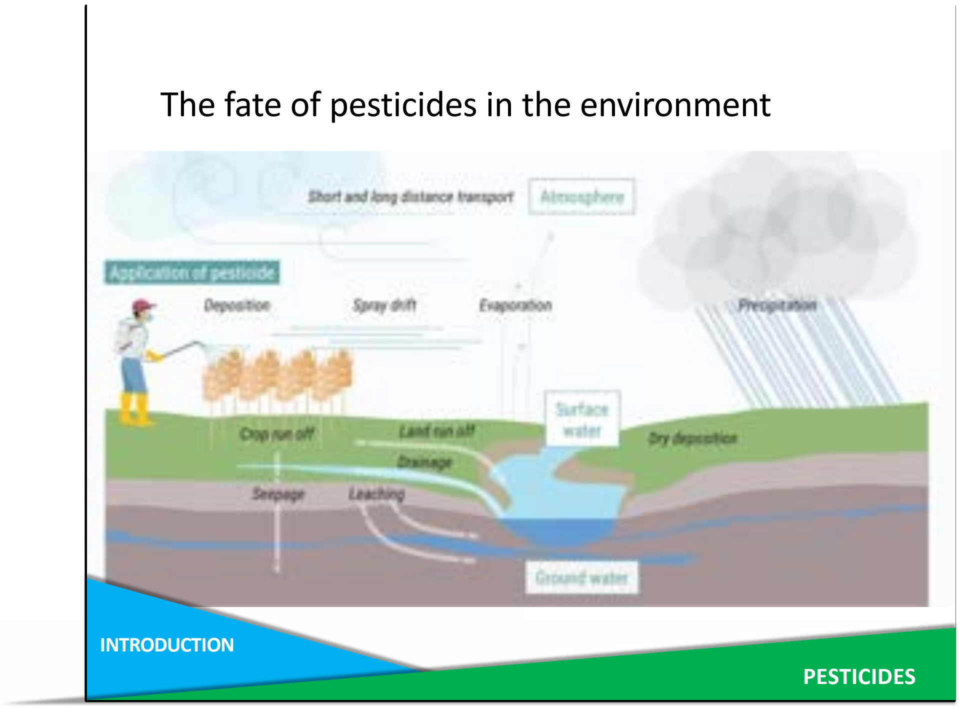

Like many chemicals, pesticides move readily through the environment, cycling through air and water and travelling around the globe via wind and ocean currents. Pesticides in water can evaporate, deposit via precipitation, and move through groundwater or surface runoff into local waterways, ultimately ending up in oceans *(1)*. Chemical properties of pesticides, such as volatility and solubility, along with local environmental conditions, including soil erosion, dust, rainfall and runoff, can all affect the quantity of pesticides that make their way into water *(2)*. Pesticides can be carried via long-range atmospheric transport to regions far from the area where they were applied and can be deposited as snow and ice. For instance, in a 2021 study, pesticides were found in ice cores from polar ice sheets in the Arctic and Antarctica *(3)*.

Pesticide pollution in groundwater can result in contamination of drinking water *(2)*.

References:
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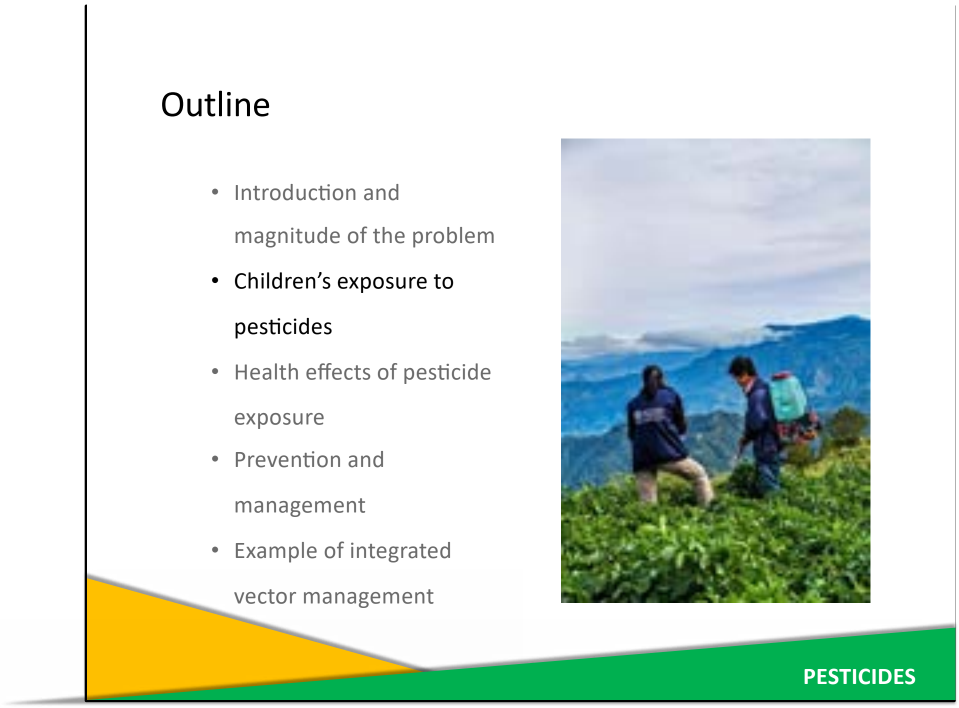
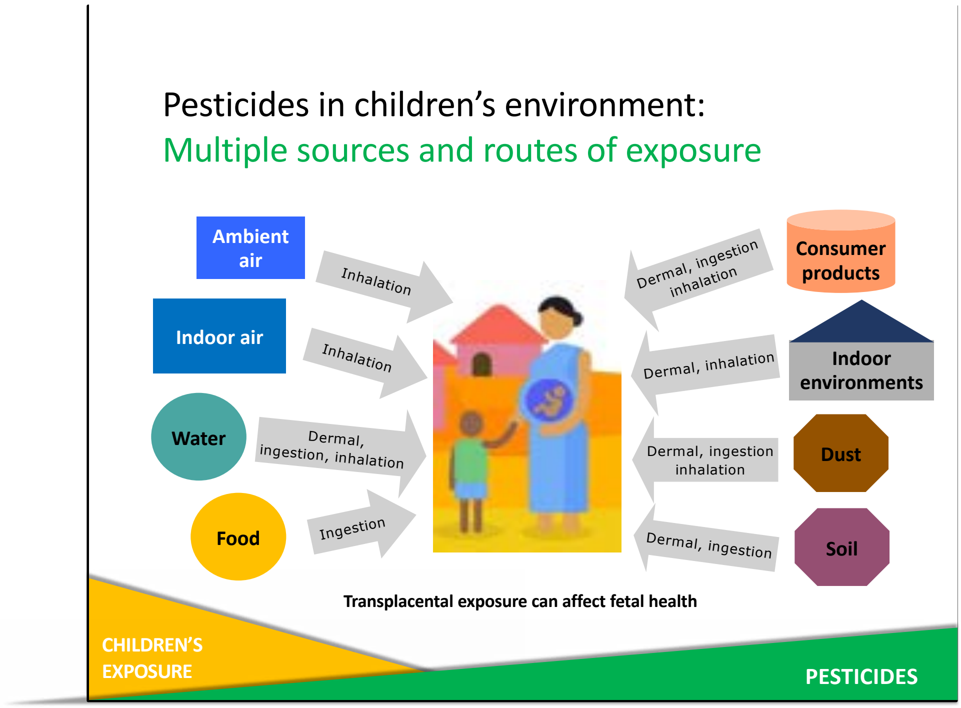
Figure:
- © UNEP/ FAO/ WHO.



The next section of this training module discusses children's routes of exposure and their vulnerability to pesticides.

Photo:

- © WHO/ Yoshi Shimizu. A farmer spraying pesticides with WHO staff.



Pesticides are ubiquitous in air, dust, soil, water and food *(1)*. They are also found in consumer products, such as mosquito repellants and products for pets, and found in indoor environments as residues on surfaces *(2)*. Depending on the source and the context, children can have multiple routes of exposure to pesticides including inhalation, ingestion, dermal and transplacental *(3)*.

- **Inhalation**: children may inhale pesticides found in ambient and indoor air, respirable droplets, spray from consumer products such as insect repellants, contaminated dust from contaminated indoor environments. Once inhaled, pesticides can reach the alveoli in the lower respiratory tract and can be absorbed into the bloodstream *(3)*.

- **Ingestion**: children may ingest pesticides unintentionally, which can result in acute poisoning. Pesticides can also be ingested in low levels from food and water sources, and through non-nutritive ingestion of contaminated soil and dust, especially in younger children *(3)*.

- **Dermal**: some pesticides can be absorbed through the skin. Children have larger skin surface area for their body size relative to adults, increasing the potential for pesticide exposure via the skin *(3)*. Normal childhood behaviours, such as crawling in grass or on floors where pesticides may have been sprayed also increase their likelihood for dermal exposure *(3)*.

- Some chemicals used in pesticide products can **cross the placenta**; consequently, exposing the fetus *in utero (3)*.

References:

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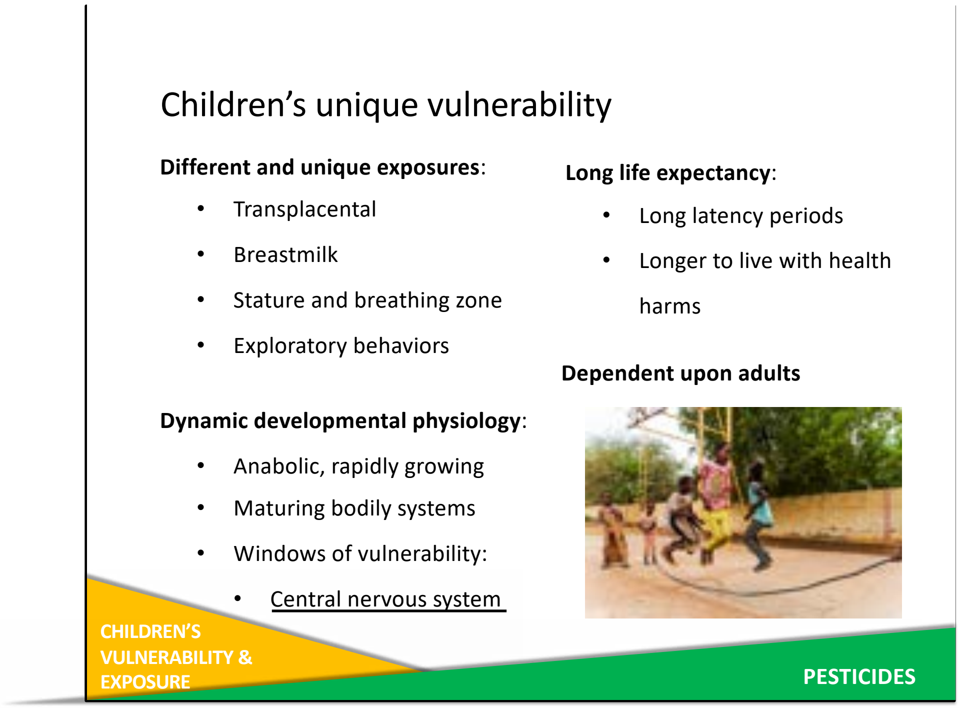
Figure:

- © WHO.



As with many environmental hazards, children are often at increased exposure and vulnerability to pesticides for several reasons.

1. Children have **<u>different and unique exposures</u>** to pesticides compared to adults. Some pesticides can cross the placenta, exposing the developing fetus to chemicals experienced by the mother *(1)*. Prenatal exposure to certain pesticides may be linked to significant health effects in children, such as some paediatric cancers and adverse neurodevelopmental outcomes *(2,3)*. Preconception exposure to some pesticides has also been associated with some paediatric cancers *(2).* As many pesticides are lipophilic, **they can also pass into breastmilk** *(1,4).* The presence of pesticides in breastmilk is not sufficient to outweigh its benefits *(1)*. Exclusive breastfeeding up to the first six months, and continued breastfeeding with complementary foods for two years and beyond, is recommended by the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) as the best source of nutrition for children *(5)*. Additionally, children have a **shorter stature and live closer to the ground than adults**. This means they may have increased exposure to pesticides that settle onto or near the ground where they play, such as grass, soil and dust *(6)*. Children also have **natural exploratory behaviours**, such as high rates of hand-to-mouth and object-to-mouth behaviours. These behaviours may increase their exposure to pesticides that have settled on dust, soil or objects *(6)*. A review published in 2017, examined pesticide metabolite levels in children living in agricultural settings and concluded that the greatest frequency of pesticide metabolite levels occurred in toddlers, was slightly lower in infants, and was lowest among older children *(7).*

2. **<u>Due to their dynamic developmental physiology</u>** children may be subjected to higher levels of pesticides found in air, water and food. **As they are anabolic and rapidly growing**, children breathe more air, eat more food and drink more water per unit of body weight than adults *(8)*. Therefore, pesticide pollution in air, food and water can result in higher internal doses in children compared to adults. Children and fetuses also have **bodily systems** that are going through **vital maturing processes** and **windows of vulnerability** *(8)*. Many pesticides are recognized as toxic to children and can cause irreparable harm to many systems and organs. Of particular concern in children is the **developing central nervous system**. Exposure to some pesticides during the prenatal period has been associated with adverse neurodevelopmental outcomes in young children *(9)*.

3. Children have **<u>longer life expectancies</u>**. Consequently, they have more time to manifest a disease with a long latency period and longer to live with toxic damage from pesticide exposure *(8).*

4. Finally, **<u>children depend upon the adults</u>** in their lives to provide a safe environment in which to grow, learn and thrive. Children living in communities that use pesticides in various settings are at risk of exposure. Infants and young children are not able to read warning labels or remove themselves from hazardous situations. Children do

not have the capability or economic means to avoid pesticide exposure from food by purchasing organic produce. Children have limited agency to affect the political decisions made at local, national and international levels that can change the use of pesticides in their environment. Children trust the adults in their lives to nurture and protect them through actions and decisions until they can protect themselves through their own individual, collective and political action *(1)*.

Note: for more information, please see the ***Children are not little adults*** and ***Why children*** modules.

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References:

- © WHO / Ala Kheir. Amna and her sisters Alia and Asmaa play with new friends in Alzahraa displacement camp.

Focus: children’s exposure to residues in food

- **Food** is the most significant source of pesticide exposure in the general population
- Data suggests widespread pesticide contamination of many commonly consumed fruits and vegetables

- Organic diets may reduce children’s exposure to pesticide

CHILDREN’S EXPOSURE

PESTICIDES

Pesticide residues on food are a major source of exposure in children. In the general population, pesticide contamination on fruits and vegetables is the most significant source of exposure *(1)*. Food can be contaminated with pesticide residues in several ways. For instance, residues can persist when crops or food animals are treated with pesticides. Food can also be contaminated by pesticides from spray drift, water used for crop irrigation and treatments applied to animal feed *(2)*.

The United States of America-based non-profit organization, the Environmental Working Group (EWG), reported in 2023 that nearly 75% of non-organic, fresh produce sold in the country contained pesticide residues. The EWG ranks the most contaminated crops sold in the United States of America (“The Dirty Dozen”), as well as the crops least contaminated with pesticides (“The Clean Fifteen”). Some of the crops in “The Dirty Dozen” are fruits and vegetables that commonly make up a substantial proportion of children’s diets, including apples and strawberries *(3)*.

Pesticide residues in food are associated with increased pesticide levels in children. For example, in a 40-day study of 149 healthy children 10–12 years of age, researchers found that children had reduced pesticide exposure as measured in urinary biomarkers for pyrethroid and neonicotinoid following provision of organic meals for the entire study period *(4)*.

The term ‘organic’ when applied to foods and diets can have different meanings depending on national and regional definitions and standards. The Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) define ‘organic agriculture’ as a “holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems *(5)*.” Additionally, the term ‘organic’ used on produce is a “labelling term that denotes products that have been produced in accordance with organic production standards and certified by a duly constituted certification body or authority *(5)*.” It is important to understand how the term ‘organic’ is applied to food in a particular context.

Note: check how organic food is defined in your country or region and highlight important features with learners.

Note: for more information see the module ***Children and food safety***.

References:

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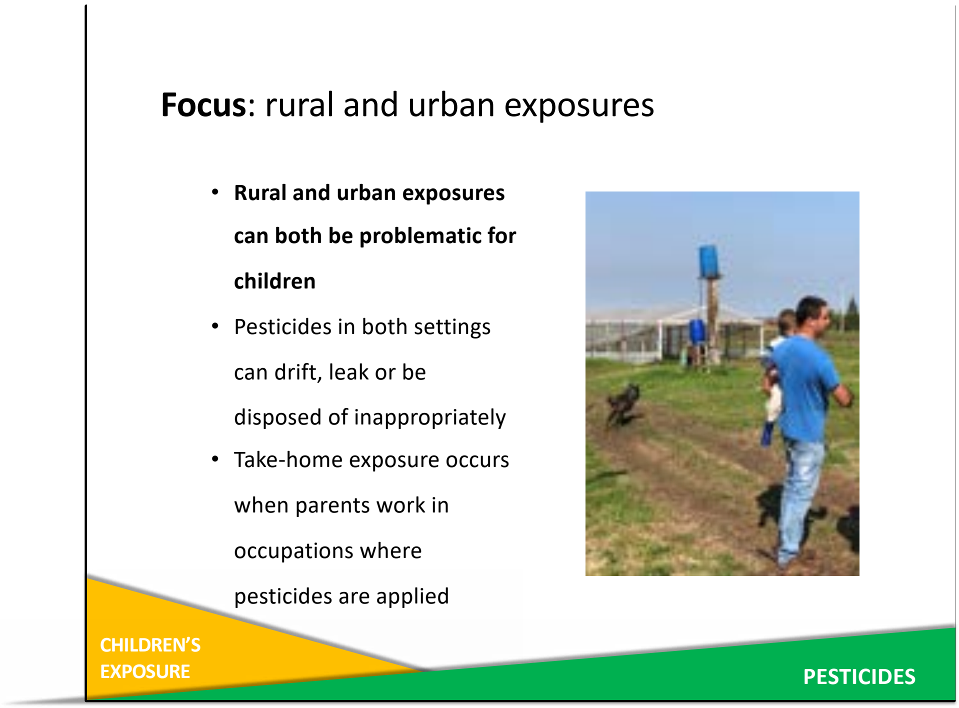
Photo:

- © WHO/ Panos/ Tania Habjouqa. Bushra, a healthcare worker with the Jordan Health Aid Society (JHAS) holds a malnourished boy while his brother points to an apple on a whiteboard at the Zaatari refugee camp.



Children living in both rural and urban areas are at risk of exposure to pesticides.

- **Rural and agricultural settings**: children living in rural and agricultural settings can be exposed to pesticides via occupational exposures and pesticide drift. As discussed on Slide 12, the agricultural industry is the biggest consumer of pesticides in the world *(1)*. They may also be exposed through 'take-home' exposure from parents or other household members who work in agricultural settings and who may carry pesticides on their clothes, shoes and skin into the home and other spaces where children spend their time *(2,3)*.
- **Urban settings**: children living in urban areas are also at risk of pesticide exposure. Pesticides are used to control pests in many urban settings such as homes, gardens, parks, commercial buildings, schools and roadways *(4)*. Pesticide residues can contaminate the application area, but also may contaminate other areas due to pesticide drift, leaks from storage sites, and improper disposal of pesticides and their packaging *(5)*.

References:

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Photo:

- Father and son who live on a horticultural cultivation farm. Their home is located close to the farm's greenhouses. The blue containers in the photo are used to prepare pesticides for spraying.

Focus: pesticide exposure in child labour

- In 2020, an estimated 160 million children worked in child labour globally
  - **Agriculture accounted for 70% of child labour globally in 2020**
- Children from families experiencing economic pressure may be at risk of child labour and pesticide exposure
- Working with pesticides:
  - 'Worst forms of child labour'
  - Associated with adverse health effects

CHILDREN'S EXPOSURE

PESTICIDES

According to United Nations Children's Fund (UNICEF) and the International Labour Organization (ILO), 160 million children globally in 2020 were working in child labour *(1)*. Agriculture was the most significant sector globally in 2020, accounting for 70% of children aged 5–17 years working in child labour. Due to the potential health harms from exposure, work which involves child labour and pesticides is considered among the 'worst forms of child labour' by the ILO *(2)*.

Families may be reliant on agriculture and the farming industry for economic stability, which can place children at risk. For instance, according to a 2018 report by the Pesticide Action Network UK, cotton farming supports over 100 million rural families every year *(3)*. Cotton farmers in low- and middle-income countries (LMICs) commonly apply pesticides with back sprayers or other rudimentary tools and may have limited or no access to appropriate personal protective equipment and training *(4)*. Risks to children working in agriculture also occur in high-income countries (HICs). For instance, children in the United States of America are allowed to work in agriculture when they are as young as 10–11 years of age under certain circumstances, provided their employers have obtained special waivers from the Secretary of Labor *(5)*. While children under 18 years of age in the United States are not permitted to apply pesticides, there are loopholes for family members of farm owners *(6)*.

While specific data is limited on child farm workers, some research has shown adverse health effects associated with spraying pesticides. For example, a 2008 study evaluated the effects on male children 9–18 years of age, who were hired as seasonal workers to spray pesticides in cotton fields using backpack applicators. Children and adolescents who applied pesticides had lower activity levels of serum acetylcholinesterase, an enzyme important for nervous system functioning, than the control group. The same children also had poorer neurobehavioural performance and reported more neurological symptoms, including blurred vision, dizziness, headaches and difficulty concentrating *(7)*.

References:

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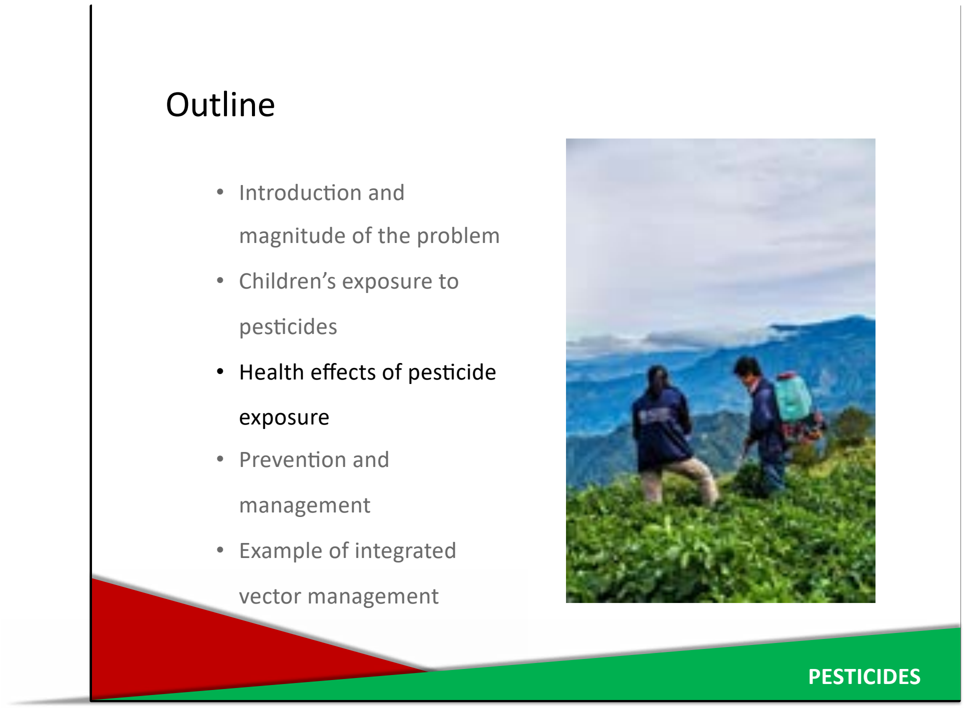
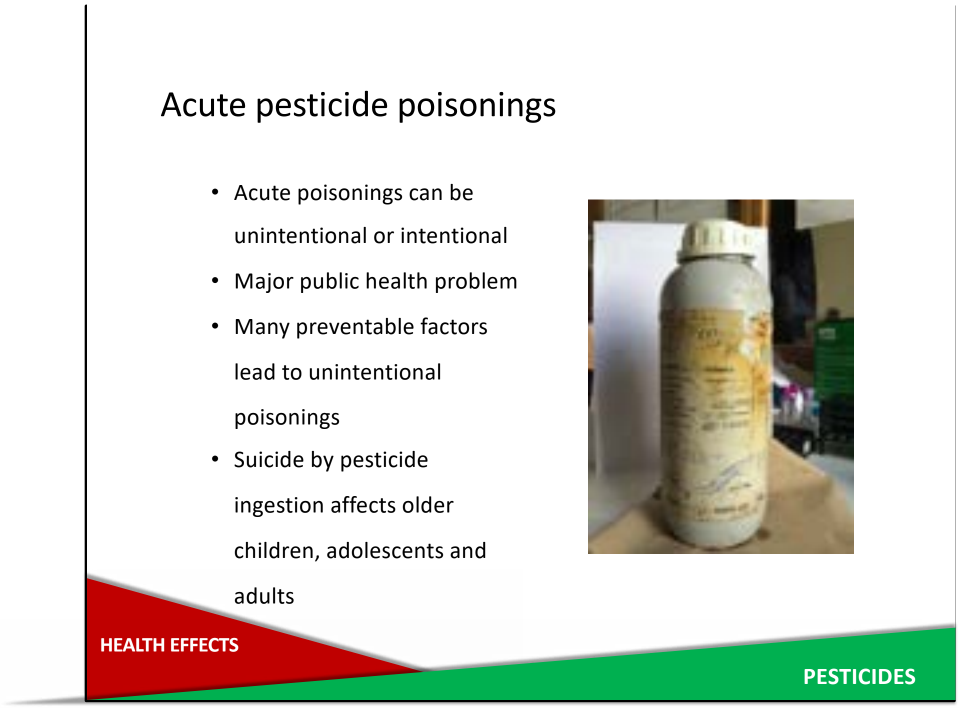
Photo:

- © Lilian Corra. Used with permission. Child working with pesticides.



The third section of this module discusses child health outcomes associated with pesticide exposure, including both acute and chronic health effects.

Photo:
- © WHO/ Yoshi Shimizu. A farmer spraying pesticides with WHO staff.



Children and adolescents are affected by acute unintentional and intentional pesticide poisonings.

There are several factors that can contribute to **unintentional pesticide poisonings in children**. Pesticides may be stored inappropriately. For example, old pesticide containers may be reused to store water and food. In some low- and middle-income countries (LMICs) pesticide solutions in soft drink bottles and other unlabelled containers have been reported for sale at public stands and stores *(1)*. Pesticide products may also be unlabelled or incorrectly labelled. Even if labelled appropriately, pesticide warnings may not be understood by children who cannot read and follow directions for use. Pesticide products used in the home may be stored where children can easily reach them. Globally, there is a significant number of unintentional poisonings every year. A systematic review in 2020 estimated approximately 385 million cases and 11 000 deaths globally are due to unintentional acute pesticide poisonings every year, with the greatest number occurring in southern Asia *(2)*. Data on paediatric pesticide poisoning are limited. The 2020 systematic review used data from the WHO mortality database and estimated that 16.6% of the annual deaths reported to the database due to unintentional acute pesticide poisoning occurred in children under 15 years of age *(2)*.

Intentional poisoning using pesticides is a major global public health concern. A systematic review published in 2017 estimated that annually 2010–2014, 13.7% of global suicides were due to intentional poisoning using pesticides *(3)*. Data on intentional poisonings in children using pesticides are very limited but existing estimates do suggest that pesticides are used by children and adolescents to inflict self-harm. For example, a 2021 study evaluated a suicide risk assessment tool and studied 100 adolescents with acute intentional poisoning from a range of different pesticides over a period of 6 months *(4)*.

References:

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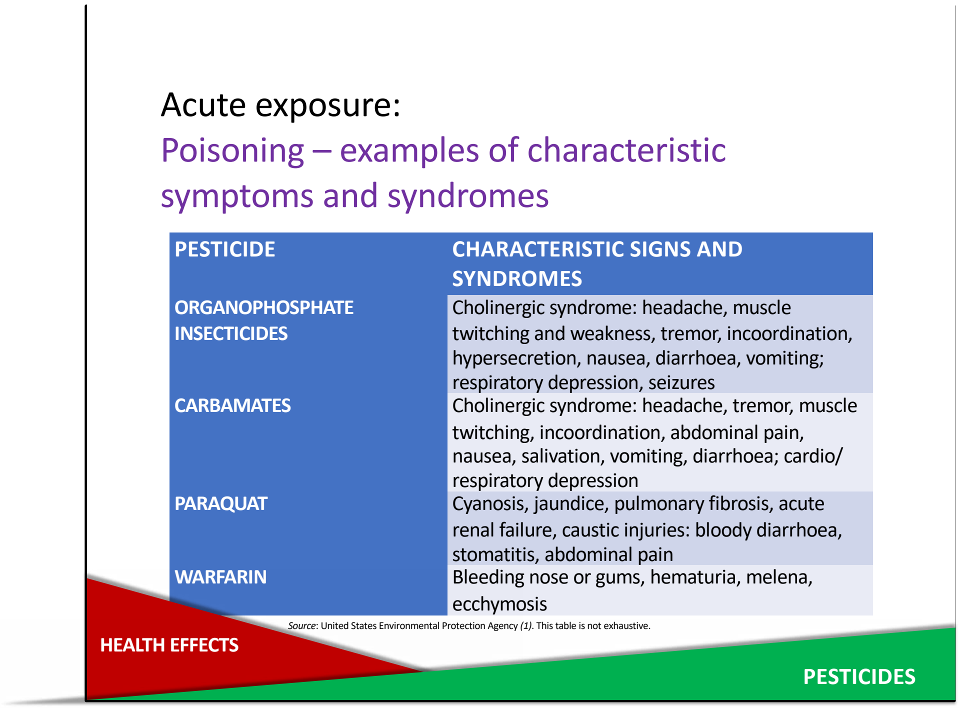
Photo:

- © Amalia Laborde. Plastic bottle containing paraquat brought by the family of an adolescent who ingested it in a suicidal attempt



Acute poisonings can have a range of different symptoms and syndromes depending on the pesticide. This slide provides some examples of common pesticides that children may be exposed to and some examples of characteristic signs and syndromes following acute poisoning. It should be noted that this table it *not exhaustive* and symptoms can depend on dose of exposure, route of exposure and age of the patient.

Some commonly used pesticides and characteristic signs and syndromes of acute poisoning include *(1,2)*:

1. **Organophosphate insecticides** lead to cholinergic syndrome (headaches, muscle twitching and weakness, tremor, incoordination, hypersecretion, nausea, diarrhoea, vomiting), respiratory depression and seizures;
2. **Carbamates** lead to cholinergic syndrome (headache, tremor, muscle twitching, incoordination, abdominal pain, nausea, salvation, vomiting, diarrhoea) and severe symptoms can include cardio/ respiratory depression;
3. **Paraquat** (a leading cause of fatal acute poisoning in many areas of the world) leads to cyanosis, jaundice, pulmonary fibrosis, acute renal failure and caustic injuries (bloody diarrhoea, stomatitis and abdominal pain);
4. **Warfarin** (a common cause of acute childhood poisoning) leads to bleeding nose or gums, hematuria, melena and ecchymosis. These usually appear several days after ingestion.

Children with suspected acute pesticide poisoning of any kind should immediately be referred to a health care provider. Poisons centres can help in recognition of the pesticide involved in a poisoning incident and provide advice on diagnosis and treatment *(2)*. For more on poisons centres see Slide 40.

Note: use reference *(1)* to find commonly used pesticides in your area and and identify the full list of possible symptoms and syndromes characteristic of acute exposure.

References:

1. Roberts JR, Reigart JR. Recognition and management of pesticide poisonings, sixth edition. Washington (DC): United States Environmental Protection Agency; 2013 (https://www.epa.gov/pesticide-worker-safety/recognition-and-management-pesticide-poisonings, accessed 11 January 2024).
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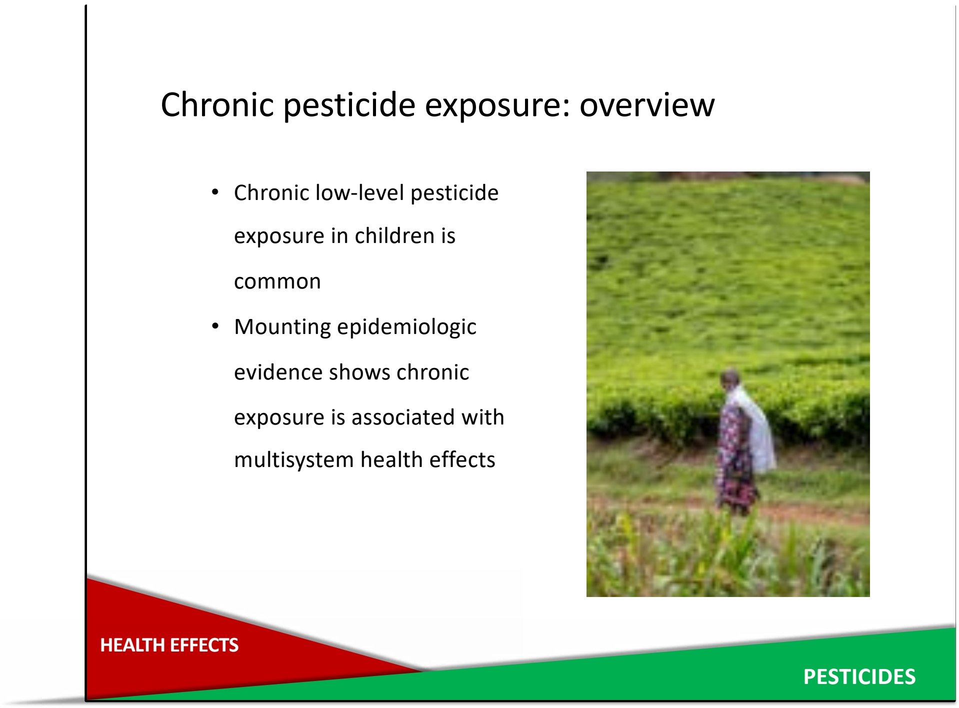

Due to the widespread use of pesticides and resulting contamination of air, food, water, soil and dust, children are chronically exposed to low levels of pesticides in their daily lives *(1)*. Mounting evidence indicates that pesticides may have multisystem effects. Low-level pesticide exposure during pregnancy and early childhood has been linked to impaired neurodevelopment, reduced lung function, endocrine disruption and some paediatric cancers *(2)*. Research challenges for assessing chronic health effects from pesticides include inaccurate exposure assessments and long latency periods between exposure and symptoms of negative health outcomes *(3)*. Despite these challenges, there is growing epidemiological evidence demonstrating associations between low-level pesticide exposures during the preconception, prenatal and childhood periods, and a range of negative health outcomes. These will be reviewed in the upcoming slides.

References:

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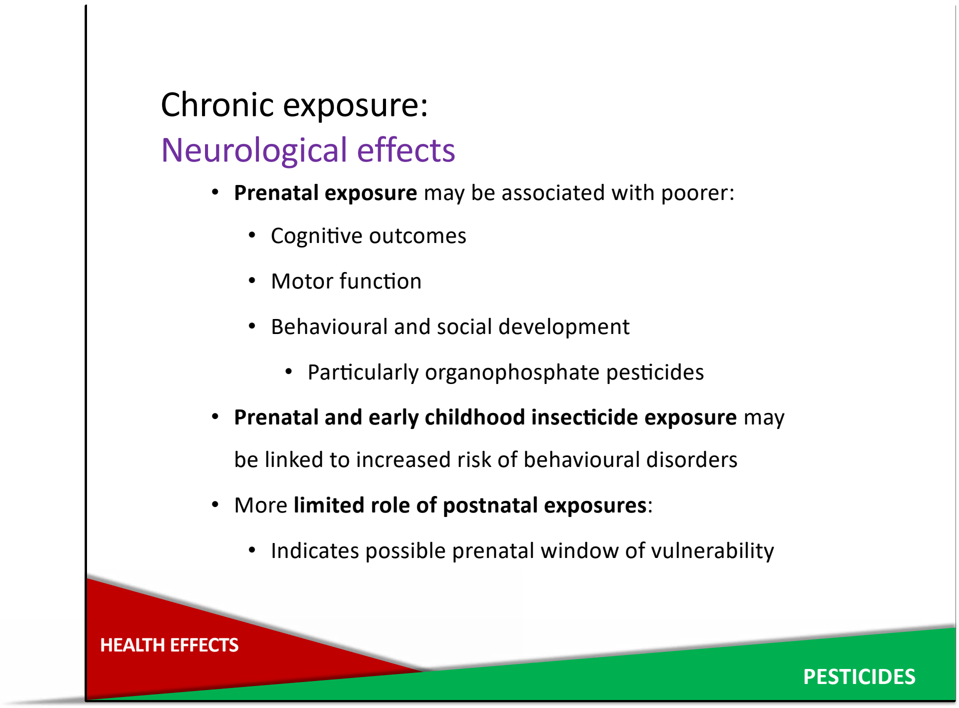
Photo:

- © WHO/ Isaac Rudakubana. Claudine heads home with her daughter after visiting a health care centre.



There is a substantial body of evidence suggesting that pesticide exposure negatively affects the development of children's nervous systems *(1)*. Possible adverse neurological effects in children may include decreased performance on tests of cognitive and motor development, as well as increased risk of some behavioural disorders *(2,3)*.

Studies have indicated an association between prenatal organophosphate pesticide exposure and adverse neurodevelopment, including poorer cognitive outcomes, delays in motor development and deficits in behavioural and social development *(4)*. A systematic review published in 2019 evaluated 50 studies completed between 1973 and 2019. It concluded that prenatal exposure to organophosphate pesticides contributes to neurodevelopmental disorders in toddlers, preschool and school-aged children. Associations between postnatal exposure to organophosphate pesticides and neurodevelopmental outcomes were limited. This suggests that the prenatal period may be the most vulnerable window for adverse neurodevelopmental outcomes due to organophosphate pesticides exposure *(5)*.

The relationship between pesticides and two major early childhood neurological disorders (autism spectrum disorder and attention deficit/hyperactivity disorder) is under investigation *(3)*. The global rate of autism spectrum disorder has increased over the past decade and environmental factors, in addition to other factors such as improved diagnosis, are thought to be contributing to the increased prevalence of such behavioural disorders in children *(3,6,7)*. A review published in 2019 concluded that pesticides may play a role in the development of autism spectrum disorder and attention deficit/hyperactivity disorder. This review also emphasized the contribution of gene-environment interactions *(3)*.

References:

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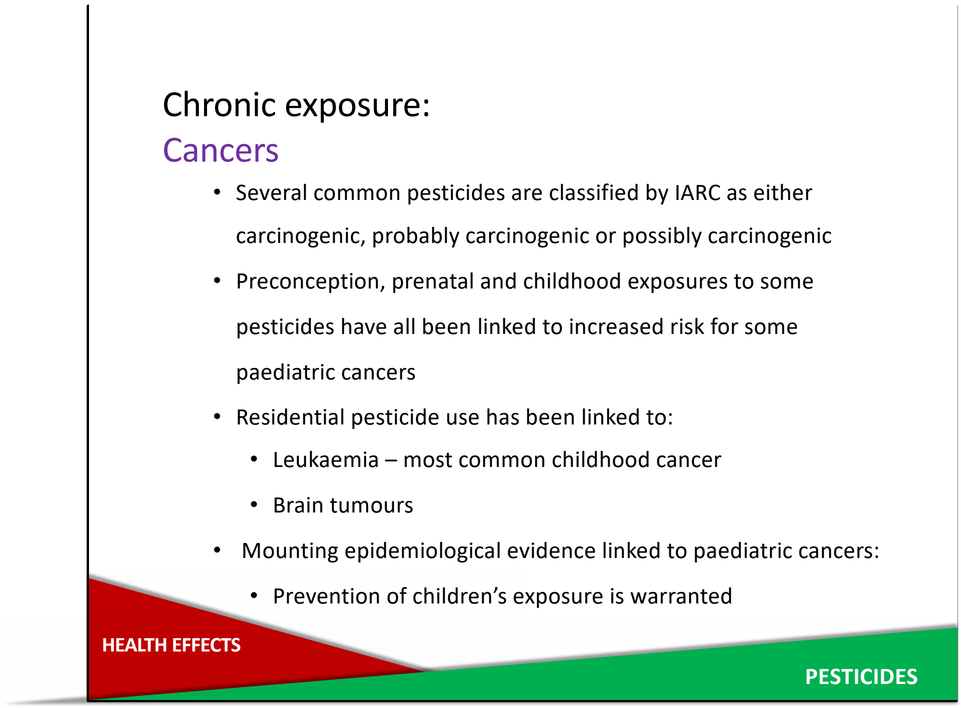

The International Agency for Research on Cancer (IARC) has classified many pesticides as either carcinogenic (Group 1), probably carcinogenic (Group 2A) or possibly carcinogenic (Group 2B). Common pesticides, such as glyphosate, which is widely used in agriculture practices, yards and gardens, are included on this list. In 2015, IARC evaluated glyphosate as a Group 2A carcinogen – probably carcinogenic to humans *(1)*.

The associations between pesticide exposure and prevalence of some paediatric cancers are strong. Both preconception and prenatal exposure windows are important for development of paediatric cancers. For instance, research has linked rates of neuroblastoma to pesticide exposure during preconception and prenatal periods *(2)*, prenatal indoor insecticide use has been associated with childhood brain tumours *(3)*, and prenatal exposure to residential pesticides, including indoor insecticides, has been linked with a statistically significant increased risk of childhood leukaemia, the most common paediatric cancer *(4)*.

Several systematic reviews and meta-analyses have been conducted and have found associations between postnatal exposure to pesticides and childhood cancers. Some of these reviews include:

- a meta-analysis of 16 studies, published in 2015, investigated residential pesticide exposure. It found that childhood exposure to indoor insecticides was associated with increased risk of childhood leukaemia and lymphoma, while herbicide exposure was associated with increased risk of leukaemia *(5);*
- a systematic review and meta-analysis conducted in 2017 concluded that prenatal and postnatal residential pesticide exposures were associated with an increased risk of childhood brain tumours *(3);*
- a meta-analysis completed in 2021 found some evidence for an association between childhood pesticide exposure and acute leukaemia, but the strength of this association was less than that for prenatal exposure *(6)*.
- one 2021 systematic review and meta-analysis found an association between childhood residential pesticide exposure and increased risk of childhood brain cancer *(7)*;
- another systematic review published in 2021 was the first to examine the relationship between exposure to pesticides and health outcomes in non-farming residents living near treated fields. It found an increased risk of blood cancers in both children and adults, although the finding was more pronounced for children *(8)*.

While most of the research investigating links between pesticide exposure and cancer focuses on childhood cancers, the potential for the development of adult cancers is also concerning due to the role that pesticide exposure may have on carcinogenesis in tissues during windows of vulnerability. For example, in a study of the association between dichlorodiphenyltrichloroethane (DDT) and breast cancer, exposure to DDT in adolescent girls during the 1950s increased their risk of developing breast cancer in adulthood *(9)*.

While long-term studies investigating associations between pesticides and cancers can be challenging to complete due to cost, long latency periods and heterogeneity of diseases *(3)*, there is sufficient current epidemiological data to support increased efforts to reduce and prevent pesticide exposures in children *(10)*.

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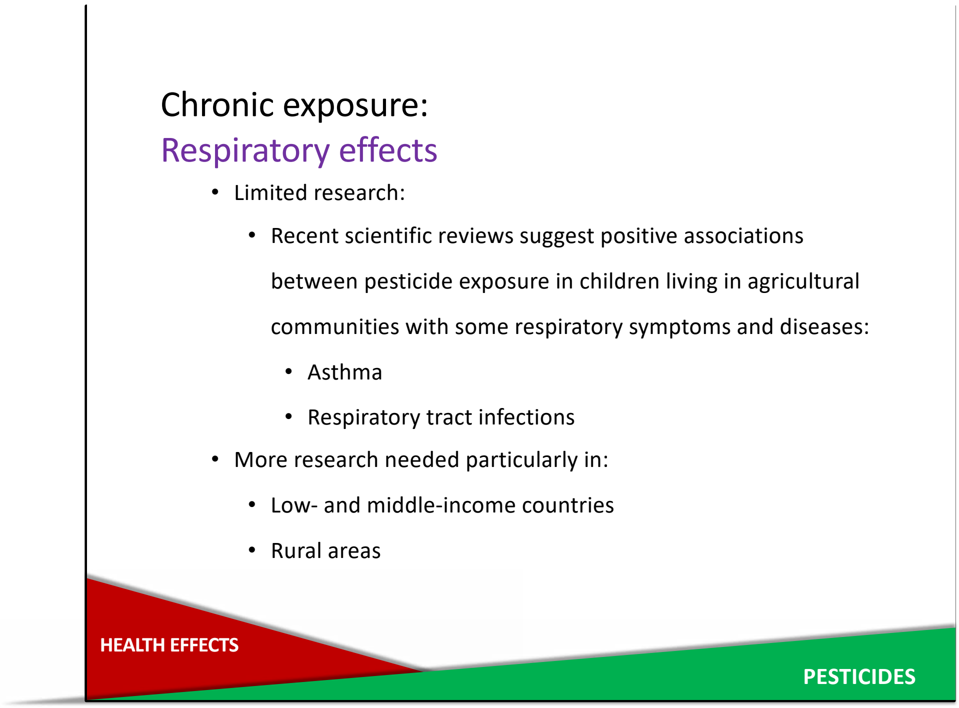

Evidence on the relationship between pesticides and respiratory effects and disease is limited and more research is needed, particularly in low- and middle-income countries (LMICs) *(1)*. Despite this, several recent reviews have reported important links between pesticide exposure and some respiratory symptoms and disease in children.

In one systematic review published in 2020, 79% of studies included found a positive association between exposure to pesticides used in agricultural practices and childhood respiratory and allergic effects, predominantly asthma *(1)*. Studies that exclusively focused on residential pesticide exposures were not included. One study included in this systematic review was conducted by the California-based Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS), the longest running longitudinal birth cohort study of pesticide exposure and other environmental exposures in children living in a farming community *(2)*. This study showed that early life exposure to organophosphate pesticides, assessed by urinary pesticide metabolites measured from birth to 5 years of age, was associated with decreased lung function objectively measured at 7 years of age *(3)*.

One review, published in 2022, conducted a systematic evaluation of research papers that studied children living in industrial agricultural areas. The review found that 18 out of 25 pesticide studies identified a positive association between exposure to agricultural pesticides and adverse childhood respiratory effects, including asthma, wheeze and respiratory tract infections *(4)*.

References:

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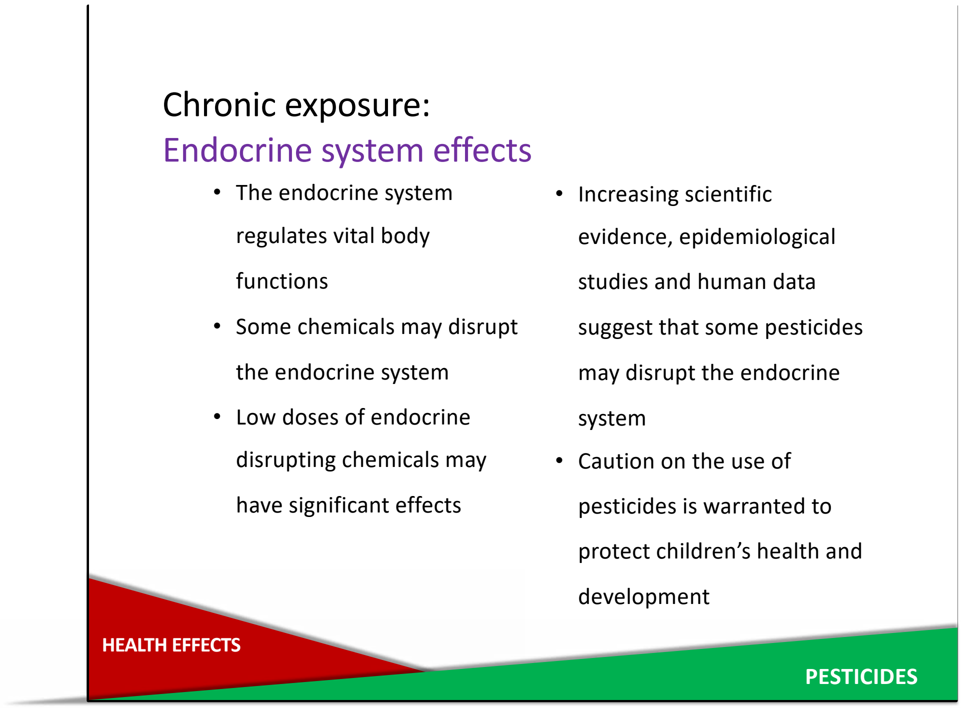

Some pesticides may have negative effects on the endocrine system. The well-known book published in 1962, *Silent Spring*, by Rachel Carson illustrated the effects that dichlorodiphenyltrichloroethane (DDT) had on pelagic bird eggs *(1)*. Currently, there is some scientific evidence for endocrine disrupting properties of certain pesticides. Epidemiological evidence and human data are accumulating *(2)*.

The endocrine system regulates vital body functions by producing, storing and releasing chemical messengers called hormones. The endocrine system is comprised of the testes, ovaries, hypothalamus, pancreas, and the adrenal, parathyroid, thyroid, pineal and pituitary glands *(3)*. Chemicals that disrupt the endocrine system are called endocrine disrupting chemicals (EDCs) *(1)*. EDCs can have a non-monotonic dose response curve, meaning that low doses may have more significant health effects than higher doses *(4)*. Studies have suggested that some common pesticides may have a range of negative health effects on the endocrine system, including atrazine, chlorpyrifos and glyphosate *(1)*.

In children, EDCs may negatively affect neurologic and sexual development *(1)*. Research has shown that EDCs can also affect thyroid function, which is important for metabolic processes and neurodevelopment. For example, a 2020 review examined the association between prenatal exposure to organochlorine compounds and neonatal thyroid hormone levels and found that some organochlorines, including DDT and its metabolite 1,1-Dichloro-2,2-bis(p-chlorophenyl) ethylene (DDE), and others, may alter fetal thyroid function *(5)*.

The possible associations between pesticide exposure and other endocrine system effects, such as obesity, are still under investigation. While the current evidence makes it difficult to draw definitive conclusions *(6)*, a precautionary approach to children's pesticide exposure is warranted to protect children's health and development *(7)*.

Note: for more information, please see the modules ***Endocrine disorders*** and ***Persistent organic pollutants (POPs)***.

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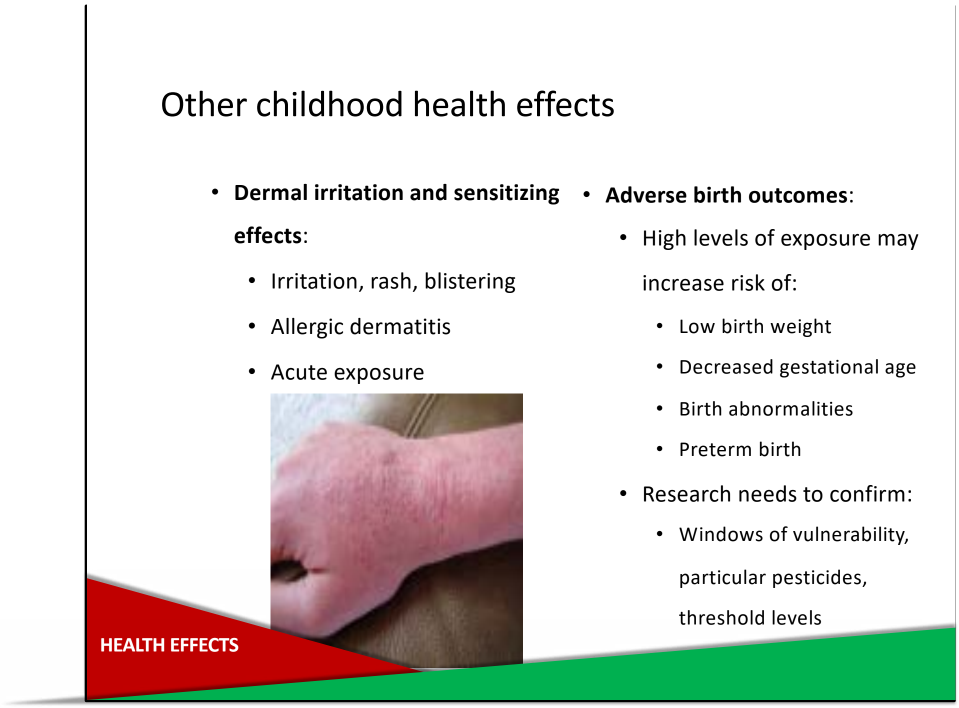

Other health effects in children associated with pesticides are being investigated and evidence is emerging. This includes:

- **Dermal irritation and sensitizing effects**: irritation is a localized effect associated with pesticide contact to the skin. Many herbicides and fungicides are strong dermal irritants. Primary symptoms usually include discomfort, redness, and localized pain. Allergic sensitization is a common effect of occupational exposure to pesticides, especially fungicides. Contact dermatitis is thought to be one of the most common effects of pesticides, through either irritant or allergic mechanisms *(1)*. Very few studies have been conducted investigating chronic exposure to pesticides and development of skin health outcomes in children. Most studies have concentrated on exposures in adult agricultural workers or acute exposures. One study of 5-year-old children found links between high levels of pyrethroid exposure and prevalence of “itchy rash” *(2)*. A systematic review published in 2022 found no evidence of links between pesticide exposure and atopic dermatitis in children or adolescents. Importantly, however, a small number of studies were included in the review *(3)*. Toxicological handbooks for health care providers illustrate a range of different dermal signs and symptoms that are characteristic of acute exposure to many different pesticides *(4)*.

- Associations between **adverse birth outcomes and pesticide exposure** is an ongoing area of study and concern. Studies on adverse birth outcomes have particularly focused on prenatal exposure to dichlorodiphenyltrichloroethane (DDT) and chlorpyrifos. A small number of studies have suggested links between pesticide exposure and increased risk of low birth weight, decreased gestational age, preterm birth and small-for-gestational age *(5)*. A study of more than 500 000 births in an agricultural region found that exposure to very high levels of pesticide during pregnancy increased the risk of adverse birth outcomes, including reduced birth weight and gestational length and birth abnormalities, by 5–9% *(6)*. More research is needed to confirm windows of vulnerability, specific pesticides linked with adverse birth outcomes and exposure threshold levels.

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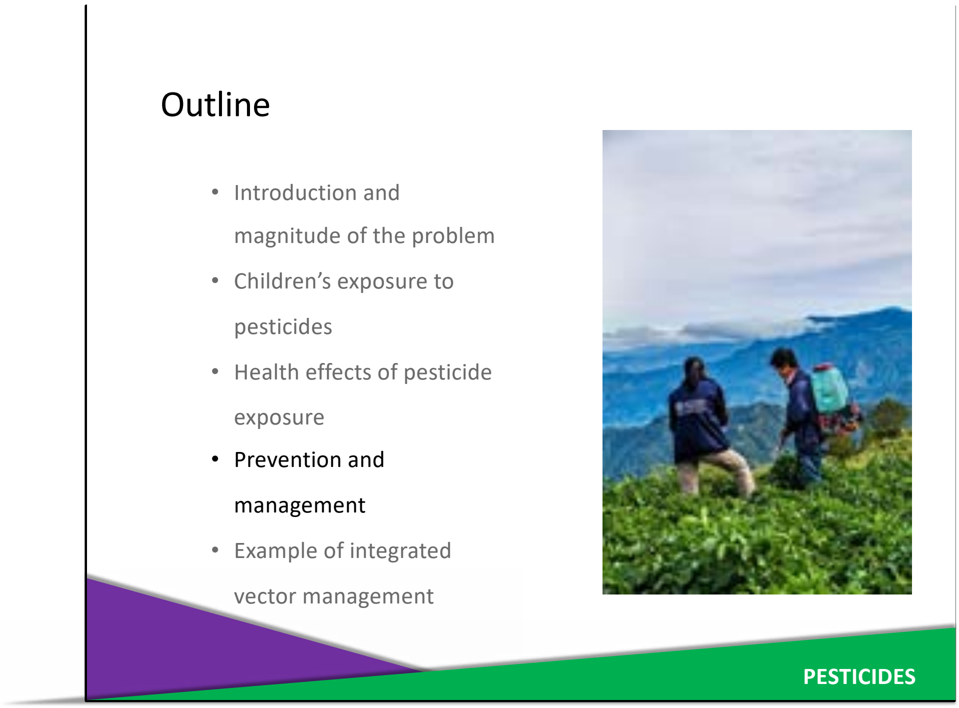
Photo:

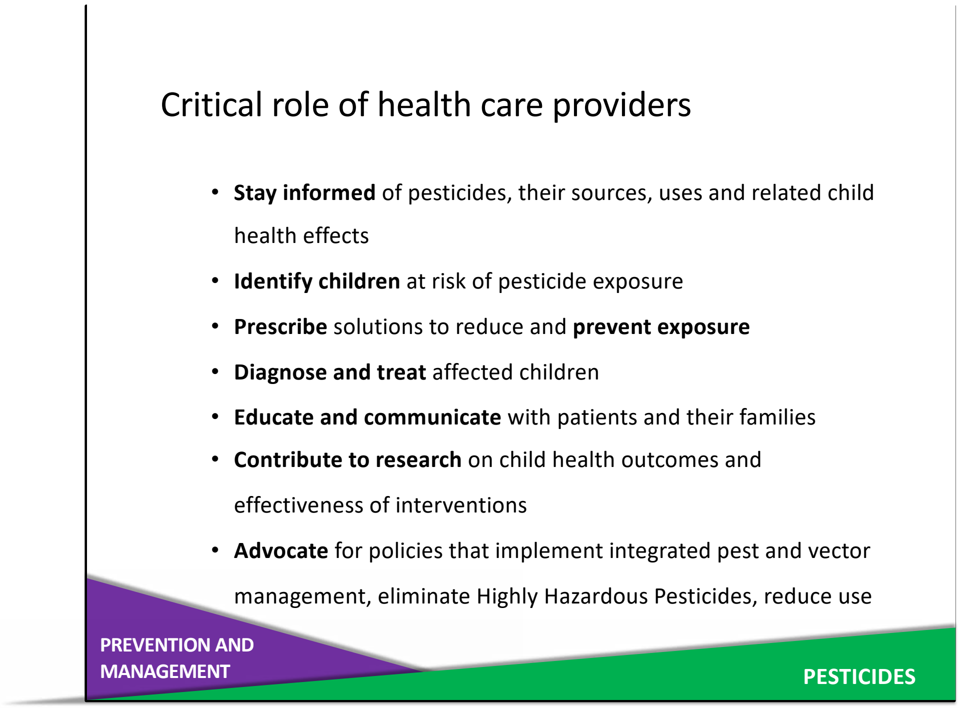
- © Amalia Laborde. Photo used with permission. Adolescent with dermal irritation after herbicide manipulation.



The fourth section of this training module discusses prevention and management ideas that health care providers can take and suggest to protect children's health from harmful pesticide exposures. It also includes national and international actions.

Photo:

- © WHO/ Yoshi Shimizu. A farmer spraying pesticides with WHO staff.



Health care providers should have a high index of suspicion for pesticide exposure in children, especially those living in agricultural communities or other areas where pesticides are known to be used regularly. From a clinical perspective, it is important to include pesticide exposure as an environmental etiology in differential diagnoses. For example, when patients present with acute symptoms such as vomiting, confusion or seizures as these could be a sign of organophosphate poisoning *(1)*.

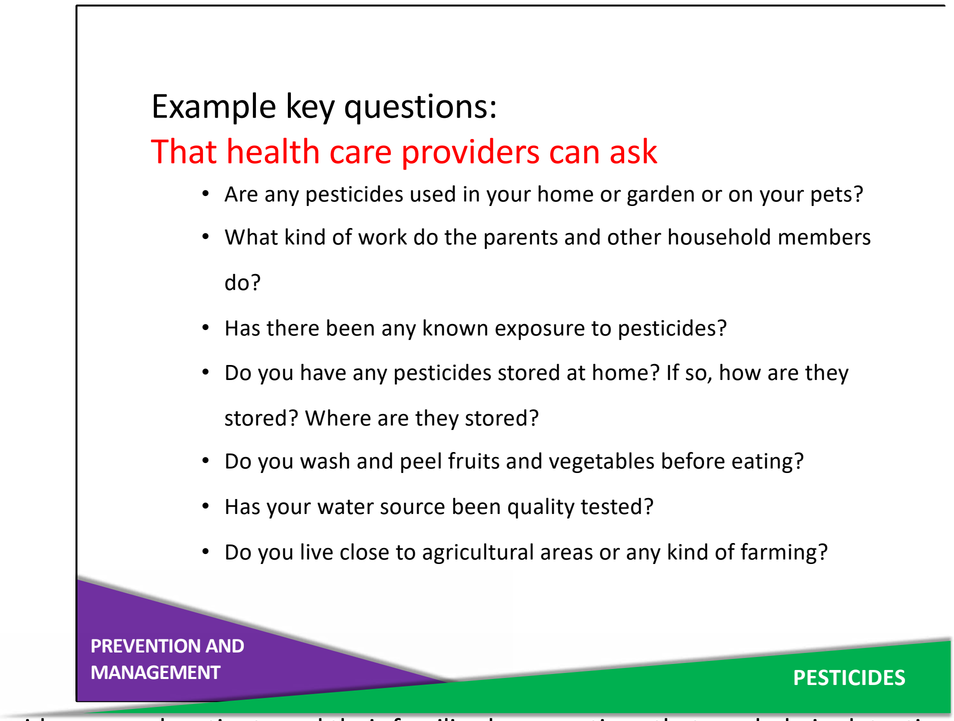
Health care providers can reduce and prevent children's exposure to pesticide exposure by *(2)*:

- **staying informed** about major classes of pesticides, their main sources and uses in the local context and associated acute and chronic child health effects;
- **identifying children at high risk of pesticide exposure**. Health care providers can identify pesticide risk factors by asking relevant questions about a child's or pregnant woman's home, community, work and school environment. For example, by asking about pest control in the home or parental occupation. Additionally, health care providers should be aware of patients who are particularly susceptible to pesticides and their health effects, for example young children or pregnant women;
- **prescribing solutions to reduce and prevent pesticide exposure**. Health care providers can use routine and well-child visits to provide anticipatory guidance for reducing and preventing pesticide exposure (see Slides 32–38 for ideas);
- **diagnosing and treating children** affected by pesticide exposure. Health care providers should be trained to prevent, diagnose and manage acute pesticide poisonings. Health care providers should also be knowledgeable about the sources and routes of chronic pesticide exposure and their possible health effects;
- **educating and communicating** with patients and their families, community members, colleagues and students about the main local sources of pesticides, risks to child health and methods to reduce and prevent exposure based on locally available resources;
- **contributing to research**, for example through case studies, studies on child health effects linked to pesticide exposure and effectiveness of prevention interventions;
- **advocating** for policies that lead to sustainable integrated vector and pest management strategies, elimination of the use and production of Highly Hazardous Pesticides (HHPs), and reducing the use of pesticides in inessential practices, such as cosmetic uses. Health care providers are well-positioned to share their knowledge with decision-makers. Health care providers can convey the health burden of pesticides to policy-makers, conduct health-based assessments, support improved standards and policies to reduce harmful exposure, advocate for monitoring, and emphasize the need to protect children.

References:

1. Roberts JR, Reigart JR. Recognition and management of pesticide poisonings, sixth edition. Washington (DC):

United States Environmental Protection Agency; 2013 (https://www.epa.gov/pesticide-worker-safety/recognition-and-management-pesticide-poisonings, accessed 11 January 2024).
2. Roberts JR, Karr CJ, Council On Environmental Health. Pesticide exposure in children. Pediatrics. 2012:130(6):e1765–88.



Health care providers can ask patients and their families key questions that can help in detecting and identifying children at risk of pesticide exposure. Key questions can help to build a paediatric environmental history, assess whether a child is suffering from symptoms related to pesticides and identify methods to reduce and prevent exposure *(1)*. These questions must be context specific to each patient.

Examples of questions that can be asked include:
1. Are any pesticides used in your home or garden or on your pets?
2. Has there been any known exposure to pesticides?
3. What kind of work do the parents and other household members do?
4. Do you have any pesticides stored at home? If so, are the pesticides kept out of reach of children? Are they kept in child-proof storage?
5. Do you wash and peel fruits and vegetables before eating?
6. Has your water source been quality tested?
7. Do you live close to agricultural areas or any kind of farming?

Note: if you have examples of questions that have been useful in your context or region they can be used here.

Note: for more information on completing a paediatric environmental history please see the module ***The paediatric environmental history***.

References:
1. The paediatric environmental history: green page. Geneva: World Health Organization; 2017 (https://www.who.int/publications/m/item/children-s-environmental-record--green-page, accessed 11 January 2024).
2. Roberts JR, Reigart JR. Recognition and management of pesticide poisonings, sixth edition. Washington (DC): United States Environmental Protection Agency; 2013 (https://www.epa.gov/pesticide-worker-safety/recognition-and-management-pesticide-poisonings, accessed 11 January 2024).

There are suggestions that health care providers can make to children, pregnant women and their families to reduce the need for pesticides and prevent exposure at the individual level. It is important to adapt these actions to the specific context of each patient.

Examples of actions that can be suggested include:

- **storing food and household waste in sealed containers** to prevent infestation of insects and rodents, consequently reducing the need for insecticides and rodenticides in the home *(1)*;
- **washing fruits and vegetables** under running water before eating and peeling them whenever possible *(1)*;
- **practising integrated pest and vector management principles** wherever possible, including using pesticides as a last resort and choosing the least toxic product (see Slides 36–38 for more information) *(2,3)*;
- when using any pesticide product, **always read and follow the product label and follow the specific instructions**. Do not over apply pesticides *(1)*;
- if pesticide application is necessary, **always choose a product that is appropriate for your needs.** Choose a product that targets the specific pest and do not choose an unnecessarily strong pesticide *(4)*;
- **never store pesticides in drinking bottles** or any container that children may mistake for food or drink *(5)*;
- **never reuse containers that previously held pesticides**;
- **always store pesticides in containers that are clearly labelled, sealed and kept out of children's sight and reach** *(1)*;
- **keeping children, toys and pets away from areas where pesticides are applied**. Do not allow children to play in fields, orchards or gardens after pesticides have been applied. Ventilate any room sprayed with pesticides *(1)*;
- **contact the local poisons centre or health care provider if you suspect poisoning** *(1)*.

Note: if you have examples of individual level actions that can be suggested in your context, mentioned them here.

References:

1. Healthy environments for health children: key messages for action. Geneva: United Nations Environment Programme; World Health Organization; 2010 (https://iris.who.int/handle/10665/44381, accessed 11 January 2024).
2. Roberts JR, Karr CJ, Council On Environmental Health. Pesticide exposure in children. Pediatrics. 2012:130(6):e1765–88.
3. International code of conduct on pesticide management: guidelines on highly hazardous pesticides. Geneva; Rome: World Health Organization; Food and Agriculture Organization of the United Nations; 2020 (https://iris.who.int/handle/10665/337126, accessed 11 January 2024).
4. CDC's environmental public health tracking: tips to limit various types of pesticide exposures [website]. Atlanta:

Centres for Disease Control and Prevention; 2019 (https://www.cdc.gov/nceh/multimedia/infographics/pesticide_exposure.html, accessed 11 J anuary 2024).
5. Protect children from pesticides! Visual facilitator's guide. Rome; Geneva: Food and Agriculture Organization of the United Nations; International Labour Organization; 2015 (https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1260531/, accessed 11 January 2024).

Pesticide products, whatever their intended use, should include written information on or attached to the packaging or container. Pesticides may come in a variety of packaging including *(1)*:

- Bottles
- Drums
- Tanks
- Boxes
- Bags
- Spray bottles
- Backpacks.

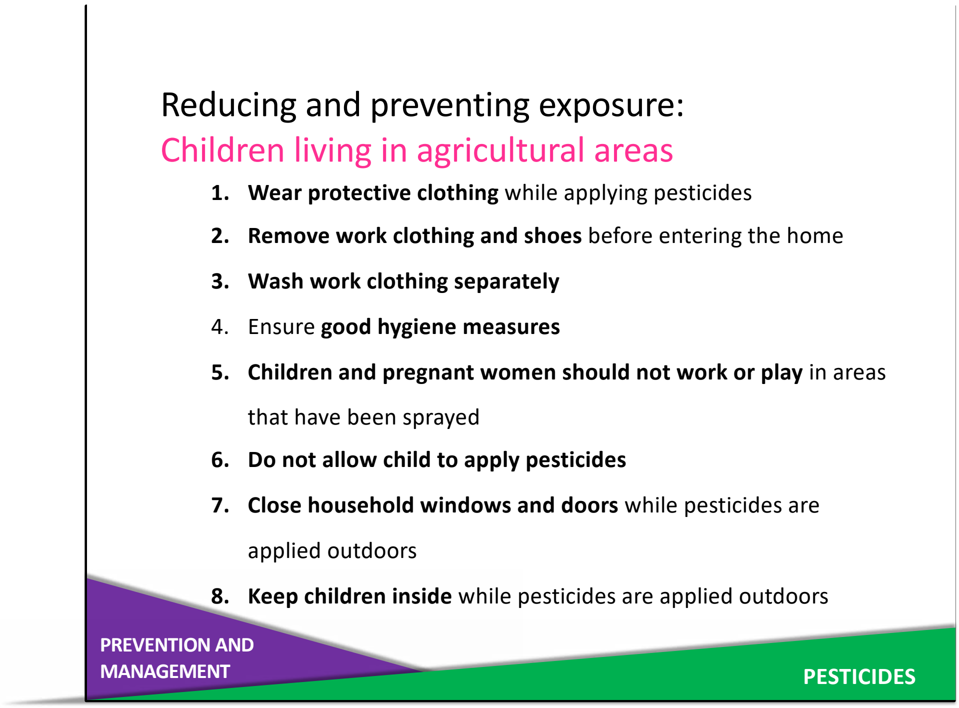
Although there is no agreed upon global standard, and differences among countries may be found, the product labelling should give basic information about the pesticide, including *(1,2)*:

1. **list of active ingredient(s)**;
2. **signal words** that indicate the level of hazard posed by a product, such as "caution," "warning," and "danger";
3. **intended use** statements informing the user of the designated purpose of the product (for example, a specific garden pest);
4. **instructions for use** informing the user how to apply the product including dilution rate and directions for frequency of application;
5. **instructions for disposal** identifying how the user can safely dispose of any unused pesticide product and its packaging;
6. **symbols that illustrate visual information about health and environmental risks of the product**. These symbols should be labelled according to the United Nations' (UN) Globally Harmonized System of Classification and Labelling of Chemicals (GHS). For example, the skull and cross bone symbolizes acute toxicity and the human torso featuring a star on the chest identifies a hazard associated with chronic or repetitive exposure (for example, an allergy or cancer). Other symbols may indicate danger to the environment if the pesticide is used or disposed of incorrectly (for example, harm to fish if a pesticide is poured into bodies of water);
7. **hazard and cautionary statements** informing the user of the primary environmental and health hazards and key recommendations to protect human health accordingly. All pesticides, independent of their level of hazard, should include the precautionary statement "KEEP OUT OF REACH OF CHILDREN";
8. **first aid information guiding the user in the event of pesticide ingestion, inhalation or contact with eyes or skin**. Importantly, it should also inform the user to contact their local health care provider.

References:

1. International code of conduct on pesticide management: guidance on good labelling practice for pesticides,

second revision. Rome; Geneva: Food and Agriculture Organization of the United Nations; World Health Organization; 2022 (https://iris.who.int/handle/10665/364033, accessed 11 January 2024).
2. Globally Harmonized System of Classification and Labelling of Chemicals, tenth edition. New York: United Nations; 2023 (https://unece.org/transport/dangerous-goods/ghs-rev10-2023, accessed 11 January 2024).



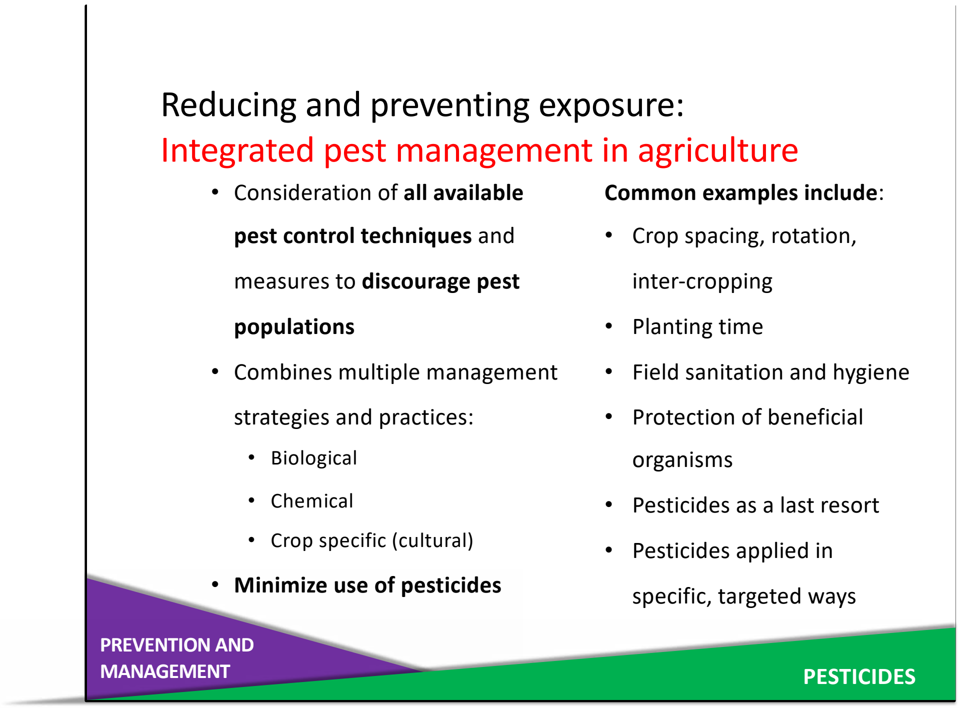
As discussed earlier in this module, the agricultural industry is responsible for most of the annual global pesticide use. Consequently, children and pregnant women living in agricultural areas are at the highest risk of exposure. There are actions that patients and their families can take to reduce children's and pregnant women's exposure to pesticides used in their communities. Health care providers can make suggestions such as *(1–3)*:

1. **wear protective clothing** while working so pesticides do not contaminate other clothes;
2. **remove all work clothing and shoes** prior to entering the home to prevent pesticides being tracked through the house;
3. **wash clothing** that has been used for agricultural work separately from other clothing;
4. **ensure good hygiene measures**. Always wash hands, face and any other body parts that may have been exposed to pesticides before entering the home and greeting others. If possible, shower before leaving work or as soon as possible;
5. **children and pregnant women should not work or play in fields** that are being sprayed with pesticides, or have been recently sprayed;
6. **do not allow children to apply pesticides**;
7. **close household windows and doors** while pesticides are being applied outdoors to prevent pesticide drift from entering the home;
8. **keep children inside while pesticides are being applied outdoors**.

Note: adapt these actions to suit your specific context and available resources.

References:

1. Protect children from pesticides! Visual facilitator's guide. Rome; Geneva: Food and Agriculture Organization of the United Nations; International Labour Organization; 2015 (https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1260531/, accessed 11 January 2024).
2. Take-home exposures – reproductive health [website]. Atlanta: Centres for Disease Control and Prevention; 2023 (https://www.cdc.gov/niosh/topics/repro/takeHome.html, accessed 11 January 2024).
3. Lucas SF, Allen PJ. Reducing the risk of pesticide exposure among children of agricultural workers: how nurse practitioners can address pesticide safety in the primary care setting. Pediatr Nurs. 2009;35(5).



The Food and Agriculture Organization of the United Nations (FAO) defines integrated pest management as "the careful consideration of **all available pest control techniques** and subsequent integration of appropriate measures that **discourage the development of pest populations** and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment" *(1)*. Integrated pest management was developed in recognition to the growing global reliance and use of pesticides in the agricultural sector, resulting in pest control crises, such as pest resurgence following development of pesticide resistance and outbreaks of secondary pests *(1,2)*.

Integrated pest management combines multiple pest management strategies and practices. These include biological, chemical and crop specific (cultural) strategies that aim to *(3)*:

- grow healthy crops
- **minimize use of pesticides**
- **reduce and minimize risks from pesticides posed to human health and the environment.**

Integrated pest management does not necessarily need to involve sophisticated technologies or high-level decision-making and can be applied across all levels of agricultural development. Management techniques depend upon several factors including local environmental conditions, available resources, local crops and pests of concern. Some common examples of practices and techniques that may be used as part of integrated pest management include *(3,4)*:

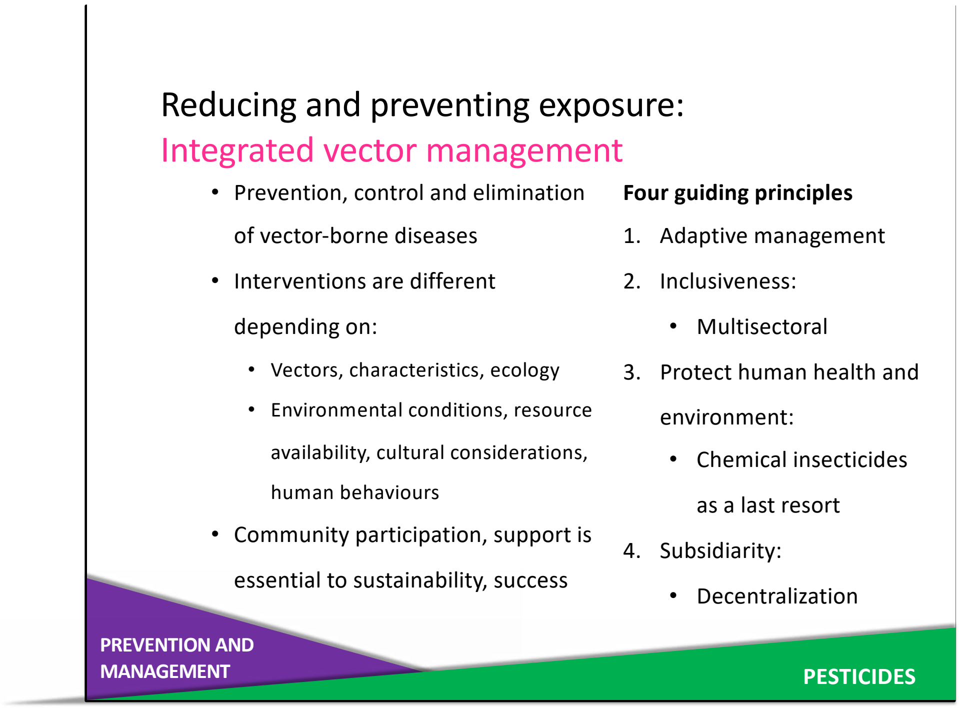
- crop spacing, which is the practice of spacing rows of crops out on a plot of land to reduce pests. The distance between each row depends upon each crop;
- crop rotation, which is the practice of planting different crops on the same plot of land;
- inter-cropping, which refers to the practice of planting multiple species side-by-side to complement each other and contribute to pest control;
- sowing seeds at optimal planting times;
- field sanitation and hygiene, which can prevent the spread of pests and harmful organisms through removal of infected plants and other similar measures;
- protection of beneficial organisms, such as bees;
- using pesticides only as a last resort when there are no adequate non-chemical alternatives and use of pesticides is economically justified;
- applying pesticides as specifically as possible to target a particular pest and reducing risks to human health, the environment and other non-target organisms.

Health care providers can work with farmers and communities affected by pesticides to spread awareness of the human health and environmental risks posed by indiscriminate pesticide use. They can also work with farmers to identify alternative methods of pest control and make connections with local programmes that are working towards integrated pest management.

Note: FAO runs integrated pest management programmes and training in several countries. Please find some examples here:
https://www.fao.org/pest-and-pesticide-management/ipm/integrated-pest-management/en/.

References:

1. Pest and pesticide management: integrated pest management [website]. Rome: Food and Agriculture Organization of the United Nations; 2023 (https://www.fao.org/pest-and-pesticide-management/ipm/integrated-pest-management/en/, accessed 11 January 2024).
2. Global situation of pesticide management in agriculture and public health. Report of a 2018 WHO-FAO survey. Rome; Geneva: Food and Agriculture Organization of the United Nations; World He alth Organization; 2022 (https://iris.who.int/handle/10665/329971, accessed 11 January 2024).
3. Pest and pesticide management: integrated pest management: principles and practices [website]. Rome: Food and Agriculture Organization of the United Nations; 2023 (https://www.fao.org/pest-and-pesticide-management/ipm/integrated-pest-management/en/, accessed 11 January 2024).
4. NSP – more about IPM [website]. Rome: Food and Agriculture Organization of the United Nations; 2023 (https://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/ipm/more-ipm/en/, accessed 11 January 2024).



Integrated vector management was influenced by developments in the field of integrated pest management. It is "a rational decision-making process for the optimal use of resources for vector control *(1)*". The World Health Organization (WHO) promotes integrated vector management as the **preferred approach to control vectors of disease**, and it can increase the efficacy, cost-effectiveness, ecological soundness and sustainability of vector control programmes *(1)*.

Vector-borne diseases, especially malaria, are a major cause of childhood mortality and morbidity. They can have long-term effects on children's social, education and economic outcomes through more sick days, reduced participation and other factors. Rather than focusing public health programmes primarily on treating vector-borne diseases, the aim of integrated vector management programmes is to **prevent, control or eliminate vector-borne diseases.** Preventing disease through vector control is an important public health method as many vector-borne diseases do not have effective medical treatments and vector control can reduce or interrupt disease transmission *(2)*. Integrated vector management programmes prevent and control disease by reducing human-vector contact and reducing vector population density and survival. Additionally, integrated vector management programmes have the added benefit of being able to target multiple vector-borne diseases at once *(3)*.

Integrated vector management programmes require evidence-based research, development and planning to be successful. Programmes will look different in different countries, towns, villages and communities depending upon local *(3,4)*:

- vectors of concern, their characteristics and ecology;
- environmental conditions, including changing conditions due to global climate change;
- resource availability;
- cultural considerations;
- human behaviours, including any locally dominant work that may affect elements of the programme.

Importantly, community participation and support are essential to ensuring sustainability and success of any integrated vector management programme *(3)*. As trusted and knowledgeable members of communities, health care providers play vital roles by working with local community members, as well as decision-makers and other sectors, to ensure that programmes are sustainable and suitable for local conditions *(4)*.

Integrated vector management is guided by four overarching principles *(4)*:

1. **Adaptive management**, which includes a decision-making process that is based on available evidence, methods and strategies, uses resources in effective and efficient ways, and uses surveillance, monitoring and evaluation to change, improve and adapt vector management programmes as required.

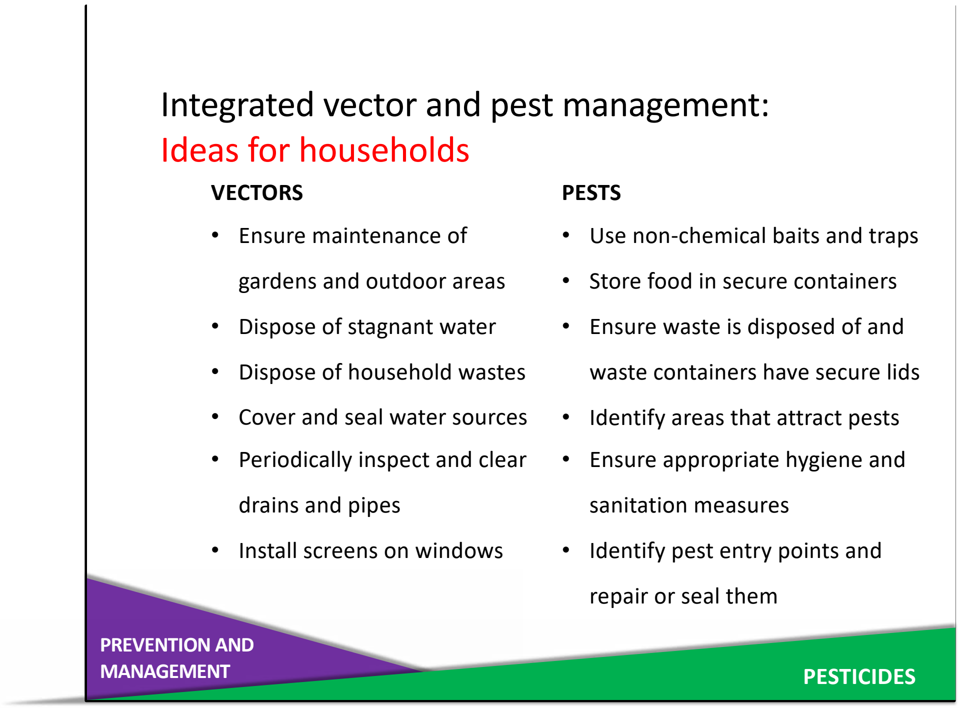
2. **Inclusiveness**, which refers to a collaborative and participatory approach to vector management programmes, including the health, private and public sectors, as well as affected communities.
3. **Promotion of human health and the environment** refers to considerations of environmental soundness and human safety when selecting methods for vector control. Chemical insecticides should be used as a last resort and alternative methods should be given priority over chemicals where feasible, acceptable and cost-effective. Alternative methods of vector control, for example environment management techniques that reduce vector sources, are effective methods of vector control and reducing the need for chemical insecticides. If chemical insecticides are used, they must be used effectively, efficiently and sustainably, with the least risk to human health and the environment as possible.
4. **Subsidiarity and decentralization** promote planning, implementation and evaluation of vector control programmes at the most local level possible.

Health care providers have important roles to play across all four guiding principles. Please see Slides 44–46 for an example of integrated vector management to reduce the burden of vector-borne diseases.

Note: WHO has an extensive range of guidance publications on integrated vector management. Please visit: https://www.who.int/teams/control-of-neglected-tropical-diseases/interventions/strategies/vector-control.

References:

1. Global situation of pesticide management in agriculture and public health. Report of a 2018 WHO-FAO survey. Rome; Geneva: Food and Agriculture Organization of the United Nations; World He alth Organization; 2022 (https://iris.who.int/handle/10665/329971, accessed 11 January 2024).
2. Berg HVD, Mutero CM, Ichimori K, WHO. Guidance on policy-making for integrated vector management. Geneva: World Health Organization; 2012 (https://iris.who.int/handle/10665/44766, accessed 11 January 2024).
3. Global strategic framework for integrated vector management. Geneva: World Health Organization; 2004 (https://iris.who.int/handle/10665/68624, accessed 11 January 2024).
4. Public health management: a course module. Geneva: World Health Organization; 2023 (https://iris.who.int/handle/10665/374300, accessed 11 January 2024).



There are suggestions that health care providers can make to patients and their families to implement integrated vector and pest management techniques at the household level and reduce the need for chemical pesticides in the home. It is important to adapt these actions to the specific context of each patient and emphasize that **chemical pesticides should be used as a last resort.**

Some ideas for action that incorporate **integrated vector management** techniques at the household level include *(1)*:
- ensuring maintenance of gardens and outdoor areas to reduce breeding areas for insects;
- disposing of stagnant water and outdoor containers that accumulate water;
- disposing of household wastes, including used tyres and other items that can accumulate water and become breeding grounds for insects;
- covering and sealing water sources, such as tanks and wells, to reduce breeding grounds for insects such as mosquitoes;
- installing screens on windows and doors to prevent insects and other vectors of disease from entering the home.

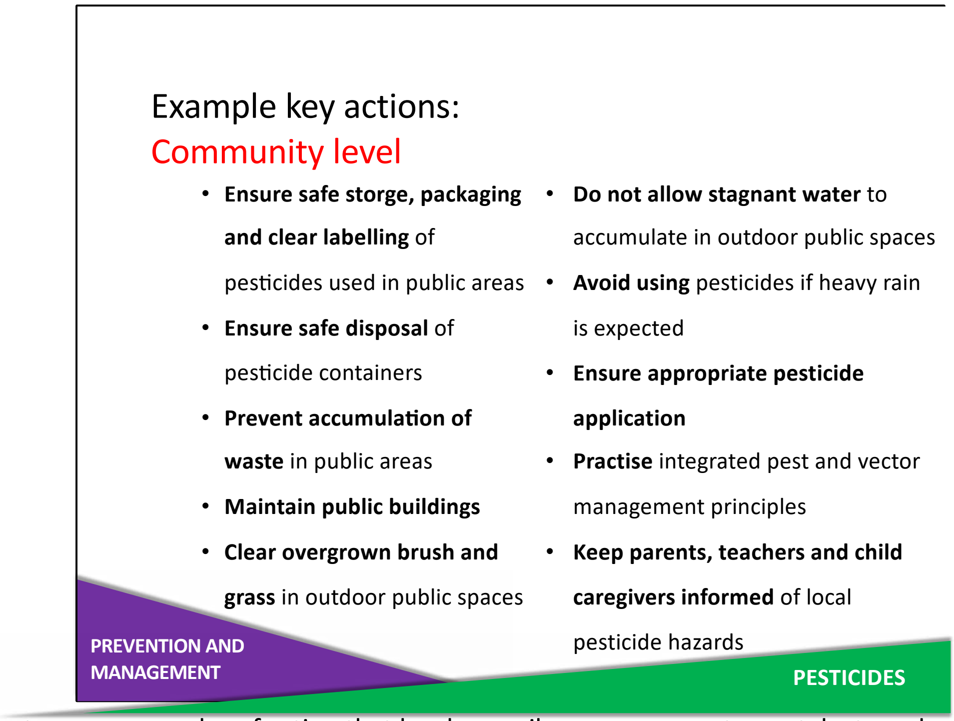
Some ideas for action that incorporate **integrated pest management** techniques at the household level include *(2–4)*:
- using non-chemical baits and traps;
- storing food in secure containers;
- ensuring waste is disposed of and water containers have secure lids;
- identifying household areas that attract pests, for example kitchens and bathrooms;
- ensuring appropriate hygiene and sanitation measures are carried out throughout the house, including timely disposal of all wastes, cleaning insect tracks with soap and water and ensuring that toilets have lids that close;
- identify places where pests may enter the home, for example cracks in the floors or walls and complete preventative repairs or seal them.

Note: adapt this slide to common vectors and pests in your context and include integrated management tips that can be taken at the household level.

References:

1. Public health management: a course module. Geneva: World Health Organization; 2023 (https://iris.who.int/handle/10665/374300, accessed 11 January 2024).
2. Home/ household IPM [website]. Corvallis: National Pesticide Information Center; 2023 (http://npic.orst.edu/pest/homeipm.html, accessed 11 January 2024).
3. Brenner BL, Markowitz S, Rivera M, Romero H, Weeks M, Sanchez E et al. Integrated pest management in an urban community: a successful partnership for prevention. Environ Health Perspect. 2003;111(13):1649–53.

4. IPM for homes: how to use integrated pest management to uninvite residential pests. Geneva NY: New York State IPM Program; 2000 (https://hdl.handle.net/1813/43849, accessed 11 January 2024).



This slide presents some examples of action that local councils or governments can take to reduce the use of pesticides in public buildings and community areas and prevent children's exposure. Health care providers can work with communities to adapt actions to the local context.

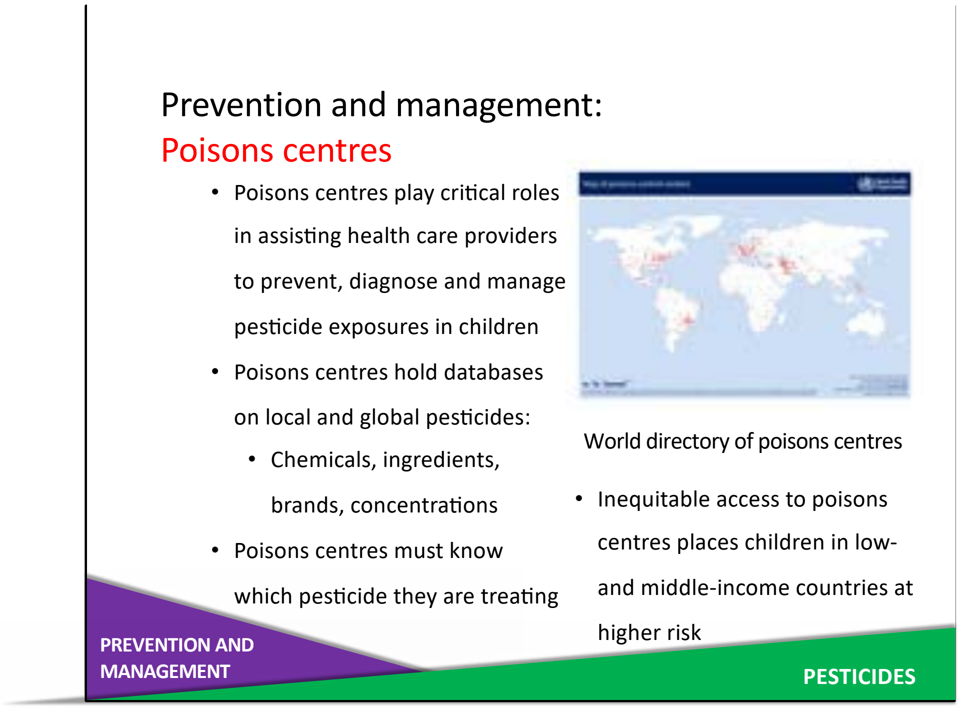
Example actions at the community level to prevent children's exposure to pesticides may include:

- **ensuring safe storage, packaging and clear labelling** of pesticides used in public areas, including buildings, parks, gardens and schools *(1)*;
- **ensuring safe disposal of pesticide containers** used for community-level needs *(2)*;
- **preventing the accumulation of waste** in public areas through regular waste collection, including on roadsides and public bins *(1,3)*;
- **maintaining public buildings**, including schools, to avoid the use of pesticides. This may include regular cleaning and repairs to prevent pests from entering buildings *(3)*;
- **clearing overgrown brush and grass** in outdoor public spaces, including on roadsides and in public parks and gardens. This can reduce available space and breeding grounds for several pests, including ticks and mosquitoes *(4)*;
- **preventing the accumulation of stagnant water** in outdoor public spaces as this can become breeding grounds for pests and vectors of disease, such as mosquitoes *(4)*;
- **avoiding using pesticides in public areas if heavy rain is expected.** Heavy rain can cause pesticides to wash into drains and local waterways *(5)*;
- **ensuring appropriate pesticide application techniques** are used in local agricultural areas and farms, including the use of personal protective equipment *(6)*;
- **practising integrated pest and vector management principles** wherever possible (see Slides 36–38 for more information) *(2)*;
- **keeping parents, teachers and child caregivers well-informed of any pesticide hazards** in local public areas where children spend their time. This may include holding information sessions, public communication to inform community members when and where pesticides are sprayed or signage on local buildings and outdoor public spaces to let community members know that pesticides have recently been applied *(2)*.

Note: if you have examples of local or community actions that have been used in your context to prevent pesticide exposure they can be mentioned here.

References:

1. Healthy environments for health children: key messages for action. Geneva: United Nations Environment Programme; World Health Organization; 2010 (https://iris.who.int/handle/10665/44381, accessed 11 January 2024).
2. Protect children from pesticides! Visual facilitator's guide. Rome; Geneva: Food and Agriculture Organization of the United Nations; International Labour Organization; 2015 (https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1260531/, accessed 11 January 2024).
3. Integrated pest management in health care facilities: implementing an IPM program. Washington (DC): United States Environmental Protection Agency; 2021 (https://www.epa.gov/safepestcontrol/integrated-pest-management-ipm-principles, accessed 11 J anuary 2024).
4. Pests and pesticides: reducing pesticide exposure [website]. New York: New York State Department of He alth; 2017 (https://www.health.ny.gov/environmental/pests/reduce.htm, accessed 11 January 2024).
5. Pesticides and consumers: tips for reducing pesticide impacts on wildlife [website]. Washington (DC): United States Environmental Protection Agency; 2023 (https://www.epa.gov/safepestcontrol/tips-reducing-pesticide-impacts-wildlife, accessed 11 J anuary 2024).
6. Bradman A, Salvatore AL, Boeniger M, Castorina R, Snyder J, Barr DB et al. Community-based intervention to reduce pesticide exposure to farmworkers and potential take-home exposure to their families. J Expo Sci Environ Epidemiol. 2009;19(1):79–89.



Poisons centres play critical roles in the implementation of international health regulations, which require countries to maintain capacity for surveillance, detection and response to public health events caused by chemicals, including pesticides. Well-resourced poisons centres are an important part of ensuring these capacities *(1)*. Poisons centres around the world track human exposure to pesticides and monitor incidences of poisoning, types of pesticides causing poisonings and their sources. Additionally, poisons centres hold important databases that can be used to identify, diagnose and treat pesticide-related poisonings. Poisons centres hold databases on both locally-used and globally-available pesticides. These databases hold a range of information on pesticides including *(1)*:

- active ingredients and chemicals
- commercial or brand names
- concentrations of active ingredients.

These databases are essential for specialists working at poisons centres. More than 1000 different pesticides are used around the world and to appropriately diagnose and treat children poisoned by pesticides, poisons centres must know which pesticide or pesticides they have been exposed to *(2)*. Poisons centres are usually required to notify government agencies of pesticide poisoning cases, especially severe and acute cases and intentional poisonings. Additionally, poisons centres play vital roles in identifying new trends in pesticide poisoning, monitoring trends and toxicity of new products, generating data and characterizing the health effects of pesticides *(1)*.

There are **fewer specialized poisons centres** in low- and middle-income countries (LMICs). In 2023, only 47% of World Health Organization (WHO) Member States had a poisons centre *(3)*. Gaps in access to poisons centres are found in the World Health Organization's (WHO) African and Eastern Mediterranean Regions and small developing island states of the Western Pacific Region *(4)*. More equitable access to poisons centres in LMICs is needed to reduce children's exposure and ensure appropriate care of those who have been exposed to pesticides. The map on this slide displays the global locations registered in the world directory of poisons centres in 2023 *(3)*.

Note: use the world directory of poisons centres to identify any centres in your country *(4)*.

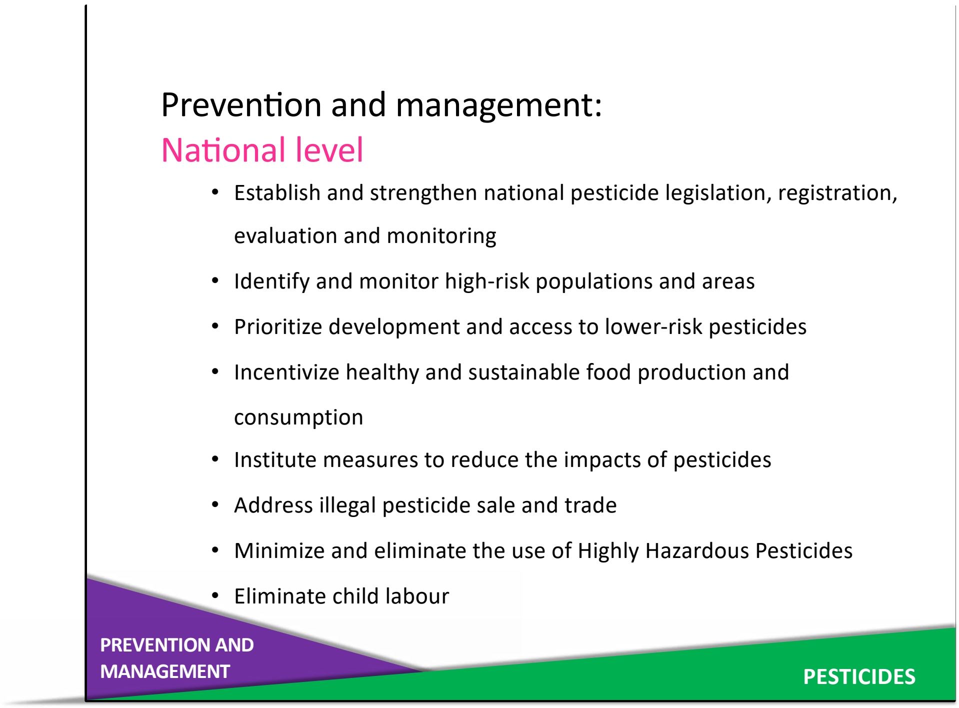
References:

1. Guidelines for establishing a poison centre. Geneva: World Health Organization; 2020 (https://apps.who.int/iris/handle/10665/338657, accessed 11 January 2024).
2. Pesticide residues in food [website]. Geneva: World Health Organization; 2022 (https://www.who.int/news-room/fact-sheets/detail/pesticide-residues-in-food, accessed 11 January 2024).
3. World directory of poisons centres [website]. Geneva: World Health Organization; 2022 (https://www.who.int/data/gho/data/themes/topics/indicator-groups/poison-control-and-unintentional-

poisoning, accessed 11 January 2024).
4. Public health impact of chemicals: knowns and unknowns. Data addendum for 2019. Geneva: World Health Organization; 2021 (https://apps.who.int/iris/rest/bitstreams/1354311/retrieve, accessed 11 January 2024).

Map:

- © WHO.



The United Nations Environment Programme (UNEP) has developed a report outlining actions that local and national governments can take to reduce pesticide use and exposure. There are many actions that governments can take, and these may depend on locally-available knowledge, resources and context of pesticide use. Government level actions may include *(1)*:

- establishing and strengthening national pesticide legislation, registration, evaluation and monitoring programmes. Legislation, policies and health-risk assessments should factor in children's vulnerabilities to pesticides. Other features of legislation may include strengthening control of pesticide distribution and use, especially of pesticides with known toxicity, and strengthening monitoring of pesticide use and their effects on humans and the environment;
- identifying and monitoring populations at high risk of pesticide exposure, such as farmers, their families, neighbourhoods close to agricultural areas and child labourers. Additionally, governments can identify and monitor environmental areas that are at high risk of pesticide contamination, such as water bodies near intensive agricultural activities;
- prioritizing development and access to lower-risk pesticides;
- incentivizing healthy and sustainable food production and consumption, such as promoting and subsidizing integrated pest management techniques in farming, the use of lower-risk pesticides and developing labelling schemes for sustainably produced food;
- instituting measures to reduce adverse effects of pesticides on the environment and human health, including ensuring training and personal protective equipment for pesticide applicators, promoting the use of modern technologies that improve pesticide efficiency and promoting cropping systems that reduce the need for pesticides;
- addressing any illegal pesticide trade and sales, such as counterfeit and substandard pesticides produced and sold by unregistered or unapproved vendors;
- minimizing and eliminating the use of Highly Hazardous Pesticides (HHPs) (see Slide 13 for more information) *(2)*;
- eliminating child labour. Children who work are not always considered child labourers. Child labour is defined as work that deprives a child of their childhood, their potential and dignity, and that is harmful to a child's physical and mental development *(3)*. As many pesticides contain chemicals that are potentially harmful to children's health, working with them is considered a form of child labour. Governments should work to eliminate child labour and work with families that are economically reliant on agriculture to ensure children do not apply pesticides and are not nearby while pesticides are applied.

References:

1. Synthesis report on the environment and health impacts of pesticides and fertilizers and ways to minimize them. Nairobi: United Nations Environment Programme; 2022

(https://www.unep.org/resources/report/environmental-and-health-impacts-pesticides-and-fertilizers-and-ways-minimizing, accessed 11 January 2024).
2. International code of conduct on pesticide management. Rome; Geneva: Food and Agricultural Organization of the United Nations; World Health Organization; 2014 (https://www.who.int/publications/i/item/9789251085493, accessed 11 January 2024).
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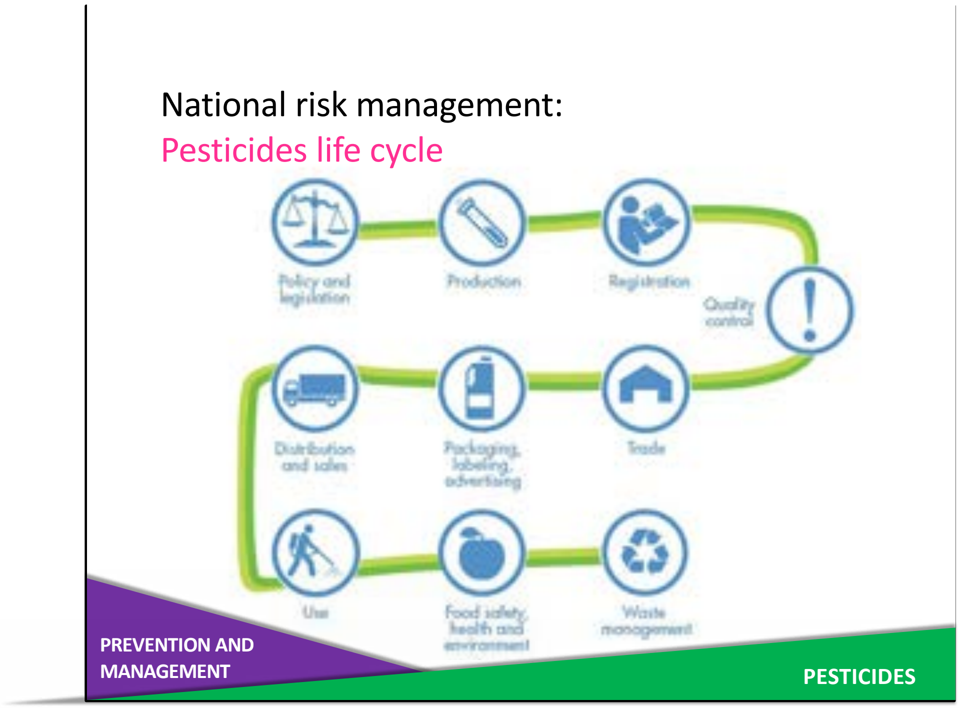

Pesticides need to be managed appropriately throughout their entire life cycle to ensure that they do not harm the environment or human health. The graphic on this slide shows the key life cycle features of pesticides, from policy and legislation through to disposal and waste management.

The World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) suggest that national governments follow the steps to reduce the environmental and human health risks of pesticide exposure *(1)*:

- **develop appropriate policy and legislation** that ensure sound management of products throughout their entire lifecycle *(2,3)*;
- **ensure that technical grade and formulated pesticide products conform** with applicable national standards or FAO specifications for agricultural pesticides, and with WHO specifications for public health pesticides *(4)*;
- **develop registrars** that evaluate and authorize pesticide registration and determine which products can be permitted for use and their purpose *(5)*;
- **ensure that quality compliance** is aligned with national pesticide regulatory systems *(6,7)*
- **uphold the requirements** of the Rotterdam Convention on the Prior Informed Consent Procedures for Certain Hazardous Chemicals and Pesticides in International Trade;
- **develop and implement guidance and regulations for appropriate, safe and informative packaging, labelling and advertising** of pesticide products *(8)*;
- **accounting for available resources, ensure that pestcides are stored, handled and distributed appropriately**. If pesticide products are stored, handled or transported using inferior techniques and conditions, their components may degrade or contaminate surrounding environments;
- **promote safe and sustainable use of pesticides**, including personal protective equipment, minimum standards for application equipment and training certification *(9,10)*;
- **monitor the presence and levels of pesticide residues in food and the environment**;
- **develop, implement and make accessible locally-tailored guidance and systems for pesticide disposal, including empty containers** *(11,12)*.

Pesticide manufacturers and governments should follow the FAO/ WHO International Code of Conduct on Pesticide Management *(1)*.

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Figure:
- © FAO/ WHO.

Pesticides are highly mobile in the environment and can travel across international boundaries. International regulatory mechanisms are essential to reducing children's exposure, especially to highly hazardous and persistent pesticides. As part of the Global Framework on Chemicals, approved in October 2023, the United Nations (UN) called for, by 2035, the phase out of Highly Hazardous Pesticides (HHPs) in agriculture where the risks are not managed, and safer alternatives are available *(2)*.

There are several mechanisms and resources in the current international framework for pesticides management. Direct mechanisms include legally binding mechanisms such as international conventions, which are legally binding treaties created by the global community with the backing of the UN to support regulation of issues that transcend national boundaries, such as hazardous pesticide use *(1)*.

Requirements for pesticide regulation are included in three major international conventions:

1. **Rotterdam Convention on the Prior Informed Consent Procedures for Certain Hazardous Chemicals and Pesticides in International Trade** *(3)*:
    - promotes shared responsibility and cooperative efforts by Parties engaged in international trade and environmentally sound use of certain hazardous pesticides;
    - aims to reduce the export of hazardous pesticides from high-income countries (HICs) to low- and middle-income countries (LMICs);
    - as of 2024, there are 165 parties to the Convention, and it covers 55 chemicals including 36 pesticides.

2. **Stockholm Convention on Persistent Organic Pollutants (POPs)** *(4)*:
    - eliminates, or restricts, the production, use and release of certain pesticides that are persistent, can be widely distributed in the environment and can accumulate in fatty tissues of humans and animals. Dichlorodiphenyltrichloroethane (DDT) is one example of a restricted pesticide under the Stockholm Convention *(5)*;
    - as of 2024, there are 186 parties to the Stockholm Convention and it eliminates, restricts or requires the reduction where possible of 39 different POPs.

3. **Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal** *(6)*:
    - aims to reduce generation and promote environmentally sound management of hazardous wastes;
    - restricts transboundary movement of hazardous wastes;
    - as of 2024, the Basel Convention has 191 parties and 14 Basel Convention Regional and Coordinating Centres are established for capacity building and technology transfer.

Other direct mechanisms are not legally binding and are voluntary. Examples of these include:

- **World Health Organization (WHO)/ Food and Agriculture Organization of the United Nations (FAO) International Code of Conduct on Pesticide Management**, which establishes voluntary standards of conduct for all public and private entities involved in the management of pesticides *(7);*
- **Codex Alimentarius**, which establishes international food standards, guidelines and codes of practice to improve safety, quality and fairness of the international food trade. The Codex sets maximum residue levels for all food and animal feed, including pesticide residues. It also maintains a database of pesticides detailing acceptable uses of each *(8)*;
- **Globally Harmonized System of Classification and Labelling of Chemicals** (GHS), which aims to ensure that information on physical hazards and toxicity from chemicals is available during handling, use and transport. It also provides the basis for harmonization of rules and regulations on chemicals at national, regional and global levels *(9)*;
- **WHO pre-qualification of vector control products** is a process which assesses vector control products, including public health pesticide active ingredients, to determine if they can be used safely and effectively and are manufactured to a high-quality standard *(10)*.

There are other resources available for global pesticide management. For example, the Pesticide Action Network (PAN) International tracks and updates a list of HHPs *(11)* and a Consolidated List of Banned Pesticides *(12)*. Additionally, an example of an indirect legally binding mechanism related to children is the Worst Forms of Child Labour Convention, established in 1999. This convention requires countries to eliminate the worst forms of child labour, including work that is likely to harm children's health, such as pesticide application *(13)*. Finally, the Global Alliance on HHPs is a voluntary, multi-stakeholder mechanism to phase out these pesticides. It is currently under development *(14)*.

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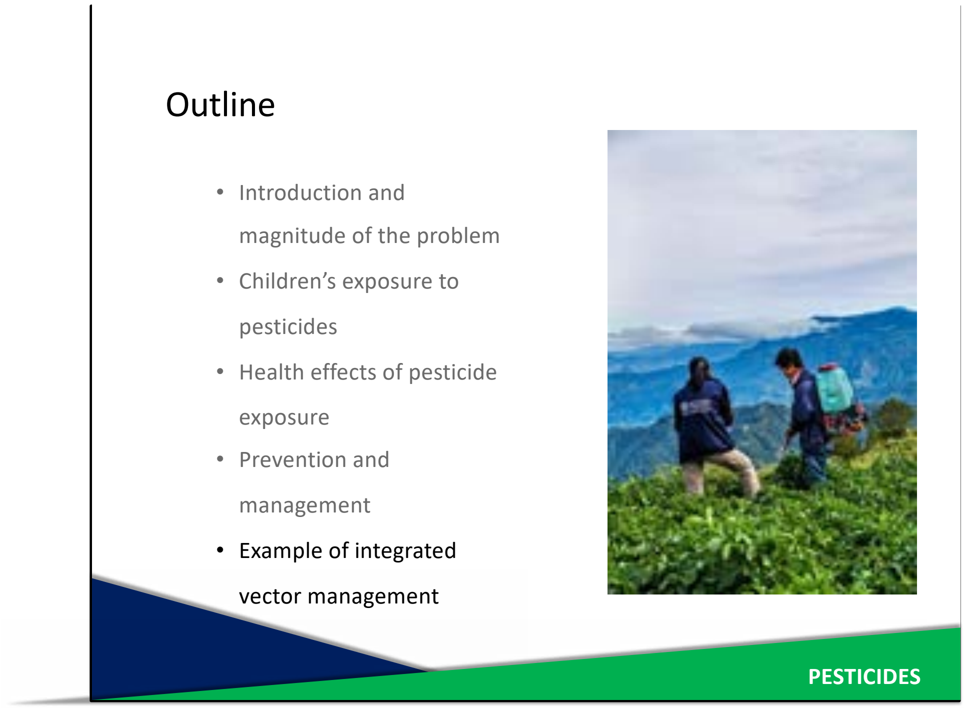
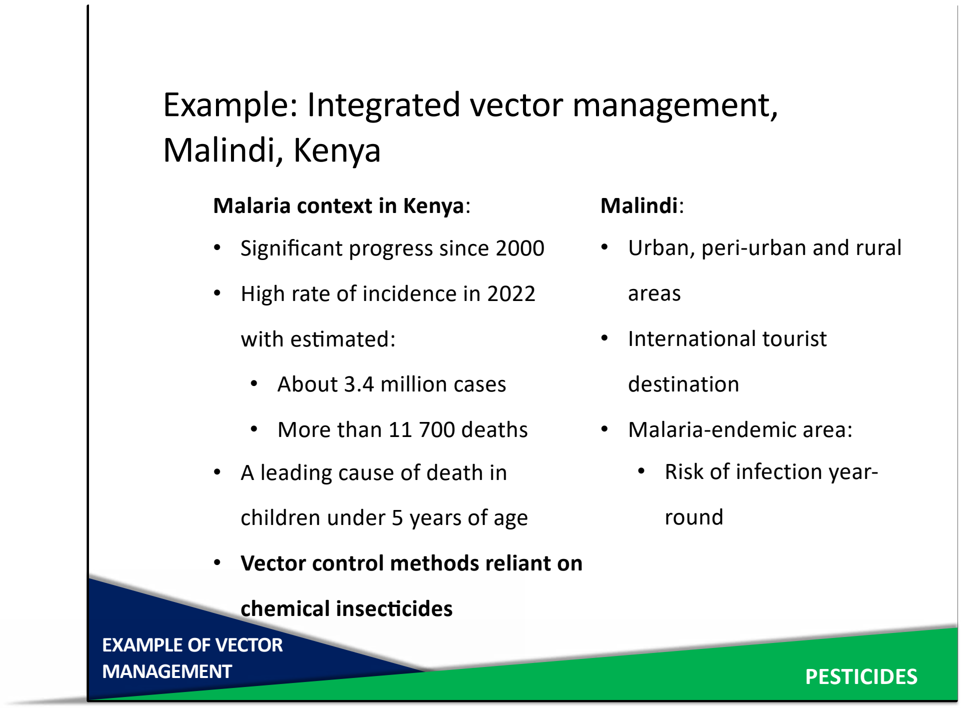


The final section of this training module illustrates an example of an intervention to reduce malaria transmission using integrated vector management techniques in a town in Kenya.

If you have appropriate examples of national or local interventions that illustrate a reduction in the use of pesticides and child health outcomes, they can be used here.

Photo:

- © WHO/ Yoshi Shimizu. A farmer spraying pesticides with WHO staff.



This example details an integrated vector management intervention in Malindi, Kenya that aimed to decrease the abundance of mosquito populations and malaria cases. It also aimed to train community members on techniques that incorporate both chemical and non-chemical methods of mosquito population control.

Globally since 2000, the number of cases and deaths due to malaria have steadily decreased. Malaria burden, however, continues to be heaviest in the World Health Organization's (WHO) African Region. In 2022, the region accounted for an estimated 94% of all cases and 95% of all deaths. 78% of all deaths due to malaria in the African Region in 2022 were in children under 5 years of age *(1)*. Kenya had a high incidence of malaria in 2022, with about 3.4 million cases and more than 11 700 deaths *(1)*. Malaria is one of the leading causes of death in both children under the age of 5 years and children 10–14 years of age in Kenya *(2)*.

Vector control in the African Region has relied almost entirely on chemical insecticide-based interventions, primarily insecticide-treated nets and indoor residual spraying. This has raised concern for the long-term effects that chemical insecticides may have on human health and the environment. Additionally, mosquito populations have shown growing resistance to a range of insecticides. Resistance to chemical insecticides is now widespread and is reported to affect all countries in the African Region *(3)*. Complementary methods of vector control are needed to continue downward trends in malaria cases and mortality rates. One intervention in the town of Malindi, Kenya used integrated vector management, including both chemical and non-chemical methods, to control mosquitoes and reduce malaria transmission *(4)*.

Malindi is a coastal town in Kenya. It is an international tourist destination, receiving thousands of tourists every year. The intervention included urban, peri-urban and rural areas of the town. Malaria is endemic in Malindi, and infection risk persists year-round *(4)*.

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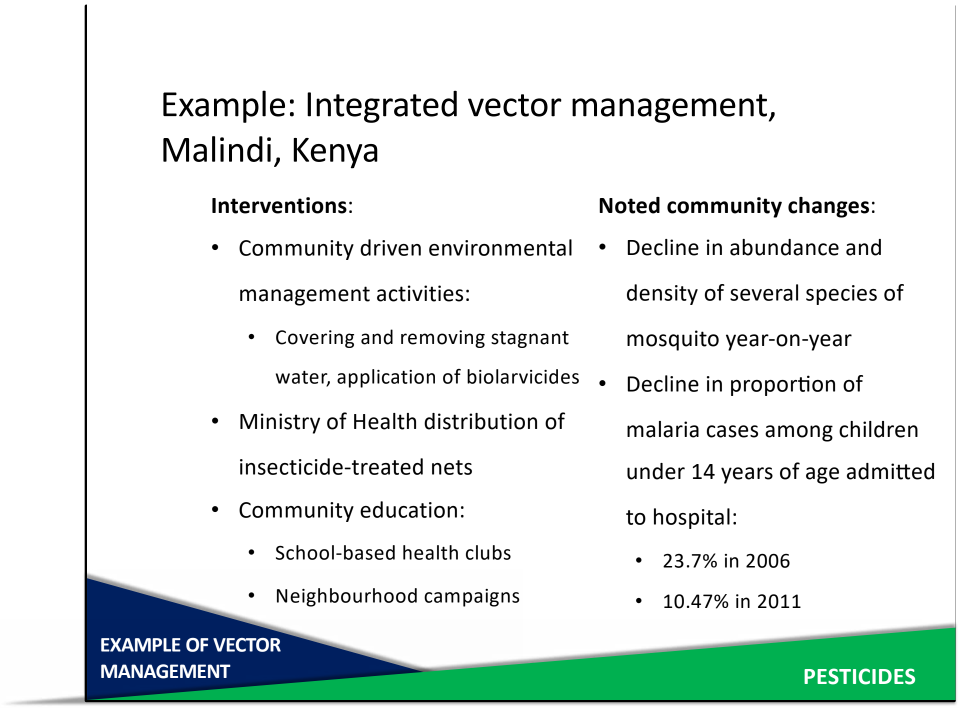

The integrated vector management intervention in Malindi was developed and implemented from 2006 until 2011 and included a broad range of activities and stakeholders from several sectors. Groups involved in the intervention included schools and community groups from across the town, national research institutes, the Ministry of Health, and international research institutes *(1)*. Some of the interventions conducted in Malindi included the following (due to space constraints, only some are listed on the slide) *(1)*:

- **community-driven environmental management activities** such as:
    - elimination of mosquito breeding sites by filling or draining stagnant water;
    - disposing of waste plastic containers;
    - covering water wells, toilets and household water storage containers;
    - application of biolarvicides (naturally occurring soil bacterium that kill mosquito larvae in water with limited negative effects on other organisms) *(2)*;
- **distribution of insecticide-treated nets, led by the Ministry of Health**;
- **community education campaigns through**:
    - school-based health clubs with the motto “Children as agents of change in malaria and mosquito control” and competitions among clubs for exemplary malaria control activities;
    - neighbourhood communication campaigns;
- **implementation of ‘mosquito scout’ programme** in which individuals were trained and responsible for surveying mosquito densities and mobilizing community activities in neighbourhoods;
- **raising awareness of the intervention** and its activities on local media and among community groups and other stakeholders.

The integrated vector management intervention in Malindi is considered successful and its achievements have been linked to its multisectoral approach and strong community participation. A narrative assessment of the intervention noted the following changes in malaria cases and mosquito populations between 2006 and 2011 *(1)*:

- declines in both abundance and density of several species of adult mosquito and larvae year-on-year;
- declines in the proportion of malaria cases among children under 14 years of age admitted to Malindi Hospital: in 2006, 23.7% of children under the age of 14 admitted to Malindi Hospital had malaria, compared to 10.47% in 2011.

References:

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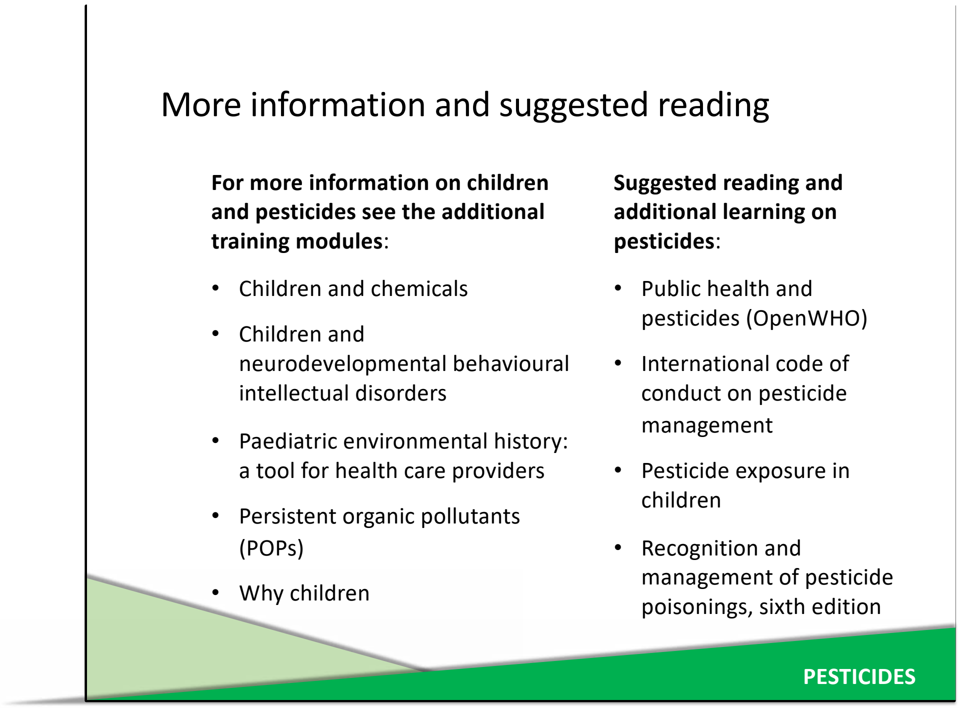

For more information on pesticides and child health please see the World Health Organization (WHO) training package on children's environmental health for health care providers *(1)*. The following modules may be of particular interest:

- ***Children and chemicals***
- ***Children and neurodevelopmental behavioural intellectual disorders***
- ***Paediatric environmental history: a tool for health care providers***
- ***Persistent organic pollutants (POPs)***
- ***Why children***.

To read and learn more on pesticides see the below suggested resources:

- ***Public health and pesticides (OpenWHO training course)*** *(2)*
- ***International code of conduct on pesticide management*** *(3)*
- ***Pesticide exposure in children*** *(4)*
- ***Recognition and management of pesticide poisonings, sixth edition*** *(5).*

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Approach to development

The World Health Organization's (WHO) Training package for the health sector is a collection of modules with internationally harmonized information and peer-reviewed materials. A team of experienced professionals from over 15 countries and nongovernmental organizations (NGOs) participated in the original conception and development of the package over several in-person workshops between 2004 and 2016. These workshops identified key areas of concern related to child health and the environment, including emerging issues, on which the global health sector requires additional training.

Subsequent updates of individual modules have been completed, including *Pesticides: training for the health care providers, second edition*. This update has been completed using a thorough literature search and review of the medical research database PubMed for relevant research published over the past 10 years. This literature search focused on published systematic reviews and meta-analyses, as well as some cohort, case-control and cross-sectional studies. WHO's online repository was searched for any relevant publications. Literature searches were also conducted across other United Nations (UN) agencies repositories for relevant reports, data, figures and other source material. Other major repositories were searched as relevant. This module also acknowledges the input from the UNICEF technical brief on "Pesticides and children's health".

All recommendations discussed in this module come from official, publicly available WHO guidelines and guidance. Other suggestions for action are *not* official WHO guidelines or guidance and are examples of local or national actions taken and are accordingly indicated and referenced.

The example of an integrated vector management intervention featured in this module was identified through expert recommendations and literature searches.

This module has been through an extensive review process with experts and has been reviewed by the relevant technical teams and departments within WHO.

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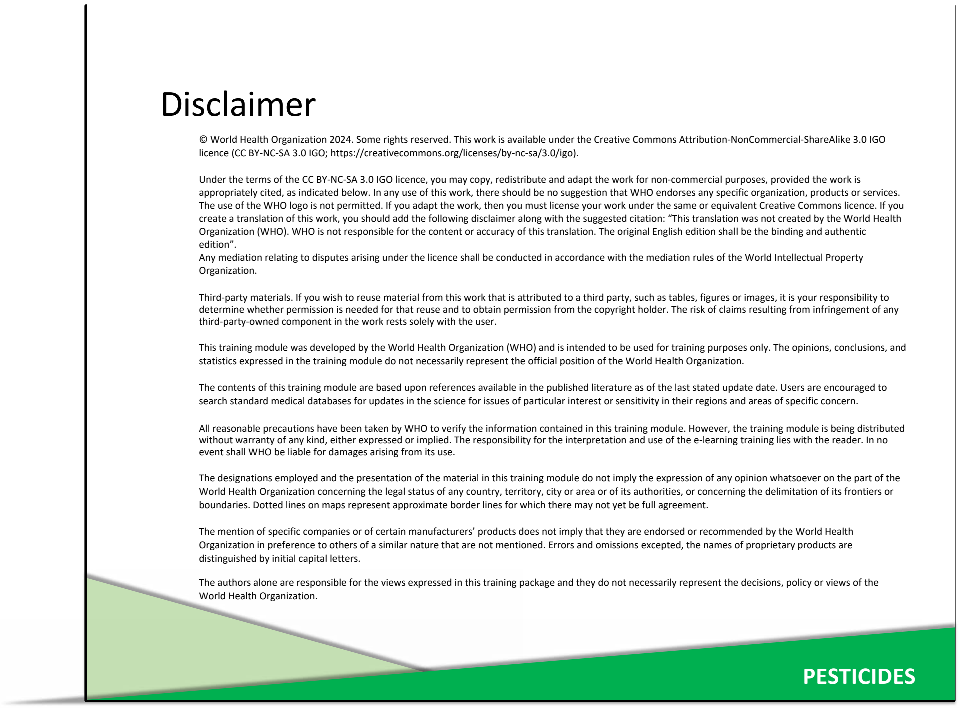

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