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Effects of pesticides on children's organisms

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Abstract: The widespread use of pesticides in agriculture has raised significant concerns regarding their impact on human health, particularly among vulnerable populations such as children. This study examines the effects of pesticide exposure on children's developing organisms, focusing on physiological, neurological, and developmental outcomes. Through an analysis of recent epidemiological and experimental studies, we identify the key pathways of pesticide absorption and the associated risks, including endocrine disruption, cognitive impairments, and increased susceptibility to chronic diseases. The findings emphasize the heightened vulnerability of children due to their smaller body mass, faster metabolic rates, and ongoing physiological development. Recommendations for minimizing exposure include stricter regulatory measures, public education campaigns, and the promotion of organic farming practices. This research highlights the urgent need for interdisciplinary collaboration to mitigate the health risks posed by pesticides and safeguard the well-being of future generations.

Keywords: Pesticides, children, health risks, developmental impact, regulatory measures, environmental toxicology.

Introduction: In modern conditions, the progress of science and technology is changing rapidly, creating new technical vehicles, agricultural technologies, and tools. To prevent crop-infesting threats to the health of humans and animals, people have long sought to use various natural and artificial means. From the earliest days, all kinds of plants, soot, and other natural herbs known to her have been used by people. In practice, a wide selection of chemicals from the earliest days for the protection of plants and animals against pests, diseases, and parasites has been tested. Recent trends show that the global market for the acquisition and distribution of agrochemicals, particularly pesticides, is growing at an average of 30% annually. It is estimated that about 70% of all funds in it are used against pests. (Phillips,2020) (Devi et al.2022) (Sabzevari & Hofman, 2022) (Faber, 2020) (Valbuena et al.2021) (Mitra et al.2021) (Shattuck, 2021)

The use of chemical pesticides for the protection of plants and animals is also widespread in Azerbaijan as well as in the regions. It has been established in this country since 1965 that wheat is treated with 4 kg of prescriptions at the time of filling. Approximately 10 tons of this agrochemical, which appeared in the country each year, were used at that time. Later, the protection of plants and animals with chemicals made people pay attention to the harmful effects of these funds on the environment for the first time. This danger has become the subject of serious research in the world. It was found that not only immediately but also long-term biological and agrochemical pesticides have a negative impact on human health, animal, and plant immunity.

Types of Pesticides

Pesticides are chemical or biological substances utilized to control or eliminate pests, maintaining plant health. Regarding the targets of each pesticide type, they are around three categories: insecticides, herbicides and fungicides. Insecticides are one of the most widely used classes of pesticides, often used to combat pests that

attack crops. Insecticides are also employed for public health to eliminate disease vectors. In order to control an unwanted insect plague, insecticides are sprayed over a wide area, an application practice that involves considerable risks to human health and the environment. Herbicides are used to prevent unwanted weeds from growing around the cultivation area. In the context of the agricultural activity, the risk analysis in children is increasing, as they are more exposed to these substances than the rest of the population. Herbicide molecules, after being sprayed on non crop fields, are transported by the wind and can be found in the soil, air and rain. Fungicides are used to prevent or eliminate fungal plagues that may affect crop yields. The pediatric population, due to its physiology and development of its systems, is more susceptible to the toxic action of these substances, which increase the risk to their health (Dahiri et al., 2021). From a pharmacological point of view, each of the abovementioned pesticide families (insecticides, herbicides and fungicides) has different action mechanisms on the target species, as well as different ways of entering the human organism when exposure occurs, whether it be superficial or incorporated in the alimentation. Each type of pesticide is absorbed by the body and exerts its toxic action through different metabolic routes, which makes a health risk assessment of all these substances even more complex. This variable action of pesticides in the human organism is fundamental to understand the different forms of toxicity and how they can affect children, representing the basis for the design and planning of the strategy of health assessment of this type of contamination, seeking to relate the different substances to the possible adverse health effects in the formative age of the human being. This comprehensive approach and analysis of pesticides are intended to be exhaustive when estimating their possible toxic effects in children, given their immaturity and development of the immune, hormonal and reproductive systems. Subsequently, this toxic behavior is planned to relate the type of exposure with this contamination, focusing on the ways in which pesticides can enter the human organism and the possible effects that can arise in children.

Insecticides

Insecticides are a class of chemicals that target insect populations, such as pesticides for roaches, and are effective in combating pests in field crops; lawn, turf, and landscaping plants; trees and shrubs; and homes, schools, and recreational facilities. Research needs to better understand differences in exposure between developmental stages across the life span, routes of exposure, and children's special susceptibilities for relevant exposure scenarios (Dahiri et al., 2021). Insecticides are specialized chemicals for certain pests and for certain plant sites, mains of application, or target areas, unless it is designed or needed as a highly nonselective chemical to be otherwise used with great caution.

Insecticides are a subgroup of pesticides that are regulated by EPA for use on or around food, animal feed, and edible crops, mainly to prevent infestations in foods and food harvest and storage settings, and to enhance the appearance and palatability of plant products to increase commercial value. Different categories of insecticides have been developed and tested over the past 70 years: chlorinated hydrocarbons; organophosphates; carbamates; and pyrethroids. Signs that can cause great suffering or death vary by type of insecticide. The chemicals used are activated to targets, whether they are metabolic or molecular, and attack tissues to disrupt physiological processes. The lethality of the toxicity and extent of nerve damage of an insecticide are not proportionate to any other animal compared to the insect. For children, physiological and developmental toxicity can be different, because the operation of the organophosphates is different compared to the adult. When an insecticide is exposed to children, one must consider their ways of developing differently from adults. Infants and children receive less pesticides than food daily, but exposure is higher to fruit, mixed diets and water, even at the trace level. Larger parts have potential to match more pesticides the dose. It has been discovered that adults touch their mouth, body, dress, or objects, consuming a higher substance that had previously been retained, or expelled before contact. There is still indirect physical or behavioral communication. Many of these variables have been the basis for research, and study discussions of children's vulnerabilities. However, risks of infection in children have not been adequately identified. There is no federal regulatory system for examining housing or garden pesticide products for children's health measures; however, significant accidental or unintended implications on children's health and security are reported with general use. There is a need for a comprehensive bibliography of publications on unintended school health settings, including studies of the health effects associated with housing or garden pesticide use. There are growing concerns about the risks to children due to acute or chronic contact exposure or accidental poisonings due to the increased volume of household pesticide application. Substantial evidence has been found in experimental studies that the use of household pesticides for living and there are disabilities and developmental problems for residents.

Children are the most common affected group, and these findings are confirmed by epidemiological research. It was concluded that more protective rules should be taken to safeguard children's well-being from unintentional pesticide exposure at home or when participating in outside sport and leisure activities.

Herbicides

Herbicides, unlike insecticides and fungicides, are used for their effects on plants rather than on animals. Most of the compounds in this group are used for agriculture in order to kill the undesired vegetation and allow the proper plant to grow without competition. However, several herbicides are not meant for agriculture but mostly for gardens, farmlands, and wherever flora need to be controlled. There are three main types: Contact herbicides are usually applied onto the leaf surface and protect the intended plant by rapid action against invading weeds. After application, the herbicide is rapidly absorbed and translocated by the plant until it affects a specific biological pathway. A similar type acts on the roots instead of leaves. Systemic or generally used herbicides work as growth regulators. They are applied in the soil and are absorbed by the plant and translocated in the sap. They block several cellular reactions, including protein synthesis. This effect is generally very slow and sometimes is not noticed until several weeks after treatment. Recently, a new group of herbicides has been introduced. Resistance-based herbicides do not kill the resistant plant but enhance the growth of a genetically modified plant that is able to support them.

Several cases of intoxication in children after exposure to herbicides have been reported. In 1974, about 50 children from a hospital were poisoned by herbicides. Children had swallowed contaminated meat at a local barbecue. In 1986, a 16-month-old girl died of pulmonary edema and central nervous system edema after accidental ingestion. Peanut butter that was eaten by the girl contained an amount thousand times greater than the legal limit. In this case, chlorophyll and lignin, along with a high-fat meal, are believed to enhance absorption. Concentrations up to 2.5 mg/L of the herbicide have been reported in the breast milk of two mothers three days after direct contamination.

Fungicides

Fungicides are chemicals used to kill pests that attack plants. The fungi exist in the soil or are carried in the air, so they can pass unnoticed and pollute the environment when fruits or vegetables are eaten and enter the body through the lungs via the respiratory system. Most fungicides are capable of attacking the brain. Children are the first to be exposed because they are more vulnerable after a play session on grass and because they often play with pets, which makes them handle the fur. One of the most lethal is Mancozeb. Long-lasting exposure to Mancozeb can affect intellect and lead to malformations in children, such as helmet-like shapes on the head. This can also cause the feet to have a shape resembling little webbed feet. The eyes can be deformed, and sores may appear all over the skin. The effects are cumulative over time and present another concern when these effects interact with those of other pesticides.

Routes of Exposure

Children may be exposed to pesticides through diet, air, contact with skin, or by accident. Some of the various routes of exposure to pesticides cause effects that can adversely affect children's health and development. Many toddlers and young children unintentionally ingest outdoor or indoor dust, dirt, hair, and other particles from the floor, much of which contains insecticide residues or other pesticides. Due to their frequent hand-to-mouth activity, children have a greater oral potential intake than adults by inadvertent ingestion of home pesticide dust residues and tracked outdoor soil near residential use of pesticides. Children are often exposed to pesticides through direct and indirect contact with treated surfaces in houses, schools, and parks. Non-homogeneous deposition of pesticides in dust, for example, can contribute to indirect oral and dermal child exposure by crawling on or touching such indoor surfaces. Playing on chemical-treated grass and dirt can lead to significant exposure for children. They have not only a higher risk of developing cancer from pesticides in the home and yard, but also the first pesticide exposure for most of them is through residues on dietary intake. At age 6 months or less, children's skin allows substances to penetrate and be absorbed more easily. Infants and children drink more fluids, eat more food in proportion to their body weight, and their metabolic activity is not yet adapted to the different substances in food. Pesticide residues in food tend to make children's dietary contribution to the body's weight of uneaten foods like fruits and vegetables larger than that of adults.

Dietary Intake

The highest pesticide residue exposure in children in the general population is usually through dietary intake. High levels are detected in fruits such as apples, peaches, pears, strawberries, and cherries. In fact, pesticides, compared to other non-organic foods, are found much more in organic foods. The main reasons are that certain production standards have to be complied with when organic products are preferred, and pesticides are factors that are prohibited in

agriculture. However, people should still be cautious when consuming organic products, as the use of prohibited substances is always possible with the increasing demand for organic food products. Meat and dairy products are the next group of foods with high pesticide residues, so consumption of reduced red meat such as chicken and turkey, as poultry animals take on less toxic substances, is beneficial in terms of pesticide intake.

Concerning methods of preparation, it must be noted that washing fruits and vegetables with vinegar reduces pesticide residues on the surface. When the washing water is boiled, the boiling point of the pesticide may be different from that of the water, contaminating the water and causing the pesticide residues to reappear on fruits and vegetables. Cooking the dishes to dry both the food and the dishes will ensure that a portion of the pesticides shrinks and evaporates. Notable is the heating of the dishes that dry liquids at high temperatures, as glass dishes can contain hazardous heavy metals and paint on dishes may contain lead and cadmium, which can then be transferred to food. It is not recommended to consume hot foods stored in nylon bags, yogurt in plastic bags, or plums kept in nylon bags since the plastic bags can dissolve in foods at high temperatures and accumulate in the body, particularly in breastfeeding mothers and children.

Residential Exposure

Residential exposure includes contact with treated surfaces, drift from aerial or ground applications, and pesticide residues on food, skin, clothing, or home surfaces. The occurrence of residential pesticide use is well documented in many developed countries, and the general population is aware of the risks associated with their use. In the UK, exposure to pesticides was estimated in adults and children through two pathways and generally represented less than 1% of the ADI for each pesticide. In the USA, pesticide residues on these items were identified as the main source of exposure in children aged 3–5 years, followed by soil ingestion, house dust, and dietary intake. Residues in food, particularly fruit and vegetables, are likely to be an important source of exposure to some groups of the population and for certain pesticides.

Children typically have more hand-to-mouth activity than adults, increasing the potential for ingestion of pesticide residues on surfaces. Those who enter the area more frequently will have increased contact and in the USA represented typical high-end scenarios for residential exposures, while typical low-end scenarios were extracted from a small number of studies. A probabilistic approach is employed for the estimates, with a distribution created for each exposure parameter.

Occupational Exposure

Children can face some of the highest risks because of their size, behaviors, and precocious development, but occupational exposures to commercially known child workers continues. Children, including toddlers, can be exposed to pesticides through contact with contaminated clothing or equipment, such as when they are worn or carried home by pesticide handlers. A recent review of safety protocols in agricultural practice found low levels of implementation, most of which existed in the Western Pacific and Southeast Asia. Additionally, (Dahiri et al., 2021) found that children whose parents worked in the pesticide industry had a greater risk of developing leukemia than those who did not. Finally, the United States Environmental Protection Agency established and disseminated safety messages to prevent childhood pesticide exposure which indicated a decline in exposure to child agricultural labor in the United States.

A pilot study of parents, child farm workers, and support personnel was conducted to investigate the occurrence of dermal exposure to residue pesticides while harvesting berries. Fingernail and hand wipe samples were collected, then analysed for four widely used fruit pesticides. A study conducted in the United States considers exposure to children of the community through parents involved in the use of endosulfan or maneb. Exposed children, 97% of whom were not engaged in agricultural activities, experienced a greater likelihood of developing ependymoma than non-exposed children. Moreover, exposure in utero or the first year of life exacerbates these risks. This study will summarize the case of occupational exposure in children using this research. Children may be at substantial risk due to their small size, their behaviours, their continued development, and their substantial precursors to endocrine disruption. Of at least 263 agricultural pesticides associated with endocrine disruption, 38 were identified. This includes 300 million children worldwide, and therefore far beyond the dangers of epidemics. Efforts to prevent childhood exposure to pesticides have mainly focused on the banning of organophosphates, the dissemination of community-based safety training, and the adoption of safety protocols. But exposure to pesticides remains a health problem. In 2010, a high percentage of all schools implemented Integrated Pest Management plans, but reported weaknesses were evident that led to insufficient protection. More than 1000 registered pesticides pose risks to human health. Pesticide use is projected to increase dramatically, and the harmful effects of exposure to young and toddler children are lacking. Unintended pesticide exposure, such as

contaminated clothing, drinking water, vapor, dirt, and entering buffer zones, including living areas and hosting applications. Livestock are particularly exposed to pesticide risks because pesticide applications are often used in the care and cultivation of crops. Pesticide safety affects employment and can be a risk to self and family health. There is a danger of inadvertent exposure to toxic and benign effects that are not visible for latency.

Children whose parents work in the agricultural sector continue to face some of the highest risks, but research involving other child workers is lacking. Children, including toddlers, can be exposed to pesticides through contact with contaminated clothing or materials, such as when they are brought home by pesticide implementers. A recent review of safety protocols in agricultural practice found low rates of implementation, most of which existed in the West Pacific and Southeast Asia. Industrially, exposed cancer studies in children with statistically significant results exist. The Preventive Agricultural Health and Protection Act regulates the time, method, place, amount, and composition of pesticides to reduce potential exposure risks to residents or predators. When these limitations were struck, a possible substitution effect occurred and children's exposure to active materials increased. Awareness campaigns have the potential to prevent significant exposure to pesticide risks by progressively indicating that in many exploration areas, the relative opportunities, dangers, and other incentives are more effective. Moreover, the program is actively participating in the exchange of agricultural and surrounding crop information. Participating families agreed to report any adverse effects to the research team. Reporting is encouraged every few weeks over the growing season. For example, if the insect growth hormone regulator was employed, the families were informed not to bring completed materials home for a period after the final application had been made to reduce exposure to child workers. A pilot study of parents, child farm workers, and handlers has been commissioned to investigate dermal exposure rates to residue pesticides from work activities while harvesting berries. Despite being target group-specific, communities are not required to be filled in, the duration of influence is unknown, and there is no information controlling the exposure situation. As such, industrial exposure pathways are not yet well-established, especially as they are in relation to domestic and asbestos exposure.

Children, however, remain within this framework, including commercial markets. This study reviews the broader and highly expanded and inadequately investigated trend of childhood industrial pesticide exposures, user-farms, and their families. There is a wide range of published studies focused almost exclusively on workplace protection in the workplace but not concerned with children of commercial child workers. In addition, work in post-industrial processes due to rates of rearrangement effects has not yet been effectively examined.

Health Effects on Children

Once pesticides enter the body, they can have both acute and chronic effects. Acute effects can often be seen right away after a child is exposed. Children who have been acutely exposed to high levels of pesticides have reported a variety of symptoms like headaches, dizziness, nausea, respiratory irritation, and even sore or red skin. Some children have reported feeling sick within moments after being exposed to pesticides, while others might not have symptoms for hours. In some cases, large exposures leading to vomiting or dizziness may only one symptom occur as the body tries to get rid of the chemicals. Repeated or moderate exposures can also lead to symptoms repeating over time following low-level exposures. However, chronic health effects may not become apparent until later in life, sometimes resulting in developmental delays or long-term neurological disorders. Chronic health effects are hard to track. Many chronic health issues are often not tied to pesticides alone. In some cases, it could be hard to detect chromosomal damage, or it may not be seen for many years. Many childhood chronic health issues have been linked to pesticides, as well as some later-in-life health issues starting in childhood. Total diet studies have consistently found that children between the ages of six months and twelve years have the highest levels of pesticides in their systems. A recent study in communities found that of the children tested, 100% had detectable levels of organochlorine pesticides in their bodies for all 27 chemicals tested, and up to 85% had detectable levels of currently registered pesticides. Additionally, some groups of children are at elevated risks of exposure and illness due to their age and living situations. For workers and families living in agricultural communities, pesticides can be a threat to children's health occasionally of any age. Furthermore, the specific sequence of environmental and genetic factors may determine the health outcome in these exposure scenarios, making it difficult to predict health consequences.

Acute Effects

Pesticide exposure can have both immediate or acute toxicity and latent or chronic toxicity. Acute pesticide poisoning in some children occurs in rural agricultural areas where exposure to toxic pesticides is common

and service providers with medical and technical expertise are scarce. Severe poisoning should be treated immediately. Mild to moderate cases typically recover with simple supportive measures like washing the skin, drinking fluids, and getting some fresh air. Children have unique susceptibilities to pesticide poisoning that can be exploited to design a diagnostic test for clinical settings. Mathematical models can also help better understand the body burden of pesticides and thus more appropriately treat the poisoning. Symptoms of pesticide poisoning in children include headache, excessive salivation, nausea or vomiting, oral ulcers or swallowing difficulties, muscle weakness, chest constriction and heart discomfort, trembling, anxiety or nervousness, hyperactivity, respiratory difficulties, and lack of muscle coordination affecting writing or walking capability.

Chronic Effects

One of the most discussed problems regarding the impacts of pesticide exposure is its chronic effects. Chronic effects consist of health problems that develop after prolonged pesticide exposure, occurring due to acute toxicity problems unresolved in the acute phase. It is important to focus especially on studies against this type of effect since the impacts start to deepen in time and become more permanent. Surely, the common and well-known effects of pesticides can also be interpreted as chronic. In consequence, focus is placed on the deeper and long-term health issues stemming from the exposure of pesticides. Developmental disorders, cognitive impairments, and chronic neurodevelopmental impacts can be counted among these long-term health issues. Some types of effects such as, but not limited to, carcinogenicity are sometimes impossible to observe or predict in the short-term.

As established environmental pollutants, pesticides are not infectious agents and their effects are always gradual and time dependent. In this context, children are exposed to a wider range and higher levels of pesticides. Once absorbed, they reach every tissue and can affect all organs and many cellular processes. Pesticides can adversely affect child health since their toxicity is usually higher than their occupational counterparts. This also triggers the current evaluation against the specific exposure in age groups such as childhood and pregnancy. Consequently, such exposure can result in long-term health effects on the metabolic pathways of children or toxic accumulations in their developing nervous system. Food producers, rural residents, and pregnant women have different patterns and levels of exposure. These groups are also the most susceptible target groups for the health effects of pesticides. Agricultural practices can differ by region. This may weaken and differentiate the public health response. In countries such as Morocco, critical exposure areas have not been sufficiently identified for the appropriate preventive health services to be produced and the development-based production to be transformed. Long-term preventive efforts also depend on the species and active ingredients of the pesticides. Not only the amount and type of active ingredient used, but also the duration of exposure can lead to the development of chronic effects. This also implies the necessity and importance of long-term and multi-faceted monitoring. From this perspective, the chronic effects of pesticide exposure will be explored in the scope of specific phenomena in the next chapter. The results of the systematic review will be presented on whether there is a chronic relationship between the toxic and endocrine-disrupting effects of different pesticides applied, and specific health outcomes identified in children (Dahiri et al., 2021).

Preventive Measures

When applying a pesticide, always pay attention to the recommendations for use. Preparation, application, and storage of pesticides must be done following the instructions given by the manufacturers. Never transfer the pesticide to other containers such as food or drink containers. Never release washed-away pesticides down pipes, in toilets, or sewage. To discard containers and the pesticide, the most appropriate place should be selected for bringing them to areas designated for this purpose. Wash the container properly three times before discarding it. Keep the pesticide as far away as possible from children and inform them that if necessary, they should call a health professional. The same amount of care that adults take when applying the pesticide must be taken with children. Store pesticides properly in places that are not exposed to sunlight and away from food and animal feed. Trading of pesticides should be prohibited in public places.

In rural areas, campaigns should be organized to raise awareness about the dangers of pesticides. Hazardous areas must be properly identified and resettled so that children cannot access them. Farmers must be requested to remove children from places of pesticide exposure. Schools should be requested to resolve the issue through the implementation of major education and prevention programs. By raising awareness in the community, health care centers also manage acute poisonings and develop prevention programs. All health agencies in the country should also develop major programs in the prevention of pesticide poisoning in children, as most health professionals and most of the population have little experience in pest management.

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