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Pesticide exposure affecting cognitive performance for children in agricultural areas

Children living in agricultural areas may experience reduced cognitive performance due to exposure to various pesticides in their daily lives. This is according to a new study conducted by scientists at the Centre for Environmental and Occupational Health Research in the School of Public Health at the University of Cape Town (UCT) and the Swiss Tropical and Public Health Institute at the University of Basel. The study is also part of the South African-Swiss Bilateral SARChI Chair in Global Environmental Health of Professors Aqiel Dalvie and Martin Röösli.

Titled "Postnatal Pesticide Exposure and Executive Function in Children and Adolescents: Findings from South Africa", the study was recently published in the journal *Environmental Research*.

The study reports on the results obtained from data collected between 2017 and 2019 from 445 school children aged nine to 16 at recruitment, attending seven schools in three agricultural areas in the Western Cape, as part of an ongoing cohort investigation. The areas include the Hex River Valley (mainly table grapes), Grabouw (mainly stone fruits) and Piketberg (mainly cereals).

Professor Dalvie said 12 of the 13 pesticides were detected among the children, with several pesticides – including chlorpyrifos, pyrethroids, hydroxy-tebuconazole, mancozeb and 2,4-D – detected in over 98% of the children.

"Higher average levels of chlorpyrifos and profenfos were associated with poorer cognitive flexibility, while higher average levels of chlorpyrifos, profenfos, pyrethroids and 4-hydroxy-pyrimethanil were associated with poorer inhibitory control," he added.

These findings, according to Dalvie, suggest that postnatal exposure to specific organophosphates, pyrethroids and triazoles may impair specific domains in executive functioning (EF) in children. He pointed out that children were expected to be more vulnerable to environmental exposures than adults due to their still-developing organs and higher dermal contact, including hand-to-mouth activities, larger food intake per unit height and body weight, breathing in relatively larger volumes of air, and playing in more hazardous zones, for example, in outdoor activities with closer contact to the ground.

"Pesticide exposure among children living in agricultural communities continues long after birth via household dust, pesticide drift and contaminated food and water. This chronic, low-level exposure during childhood and adolescence – periods marked by intense brain maturation, synaptic pruning and neural reorganisation – may lead to cumulative neurotoxic effects that compromise neurocognitive development," he said.

Dalvie noted that these effects may be especially pronounced in domains such as EF, which follow a protracted developmental trajectory. EF is an umbrella term for a set of higher-order cognitive processes that enable goal-directed behaviour, problem-solving and self-regulation. Core EF components include inhibitory control (the ability to suppress impulsive or inappropriate responses), working memory (the capacity to hold and manipulate information in mind), and cognitive flexibility (the ability to shift attention and adapt to changing demands).

"These processes are predominantly governed by the prefrontal cortex, which undergoes significant development from childhood into early adulthood. EFs are critical for academic achievement, behavioural regulation and long-term success. Disruptions to EF due to environmental agents like pesticides are particularly concerning, as they may hinder children from reaching their full developmental potential," he said.

As pesticide exposures during childhood and into adolescence coincide with critical developmental windows, Dalvie said neurotoxic effects on EF may be particularly pronounced.

"Early childhood through adolescence is a sensitive period marked by rapid cognitive development and neural plasticity. Chronic exposure during these vulnerable stages may translate into enduring impairments in attention, problem-solving flexibility and self-regulation, skills crucial for success across academic, social and occupational domains.

"In South African agricultural communities, children's pesticide exposures are often exacerbated by factors such as proximity to treated fields and weak enforcement of protective measures."

South Africa has the highest application rates of pesticides in Sub-Saharan Africa. There are over 3 000 different pesticide product formulations registered, some of which may contain neurotoxic and endocrine-disrupting chemicals. A 2017 study conducted in the Western Cape found that farms growing stone fruits, grapes and wheat used up to 96 active ingredients, including 47 fungicides, 31 insecticides and 18 herbicides. Scientists are advocating for stricter controls regarding the registration, sale, management, storage, packaging and various post-sale processes of pesticides.

"Given that these participants are not in occupation, a recommendation is to implement targeted interventions in agricultural populations, such as an educational programme on pesticide-related activities in schools, and to learn from current interventions and their effectiveness," said Dalvie.

He said that the findings also underscore the need for regulatory and public health responses that prioritise exposure reduction, especially in high-risk and underrepresented settings such as rural South Africa.

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