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Organophosphorus pesticide exposure and neurobehavioral performance in Latino children living in an orchard community

Jaime Butler-Dawson[a], Kit Galvin[b], Peter S. Thorne[a], Diane S. Rohlman[a,c,*]

[a] Department of Occupational and Environmental Health, College of Public Health, University of Iowa, Iowa City, Iowa, United States
[b] Department of Environmental and Occupational Health Sciences, School of Public Health, University of Washington, Seattle, Washington, United States
[c] Oregon Institute for Occupational Health Sciences, Oregon Health & Science University, Portland, OR, United States

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ABSTRACT

Children living in agricultural communities have a greater risk from pesticides due to para-occupational pathways. The goal of this study was to assess the impact of exposure to organophosphorus pesticides on the neurobehavioral performance of school-aged Latino children over time. Two exposure measures were used to estimate children's pesticide exposure: parent's occupation (agricultural or non-agricultural) and organophosphate residues in home carpet dust samples. During 2008–2011, 206 school-aged children completed a battery of neurobehavioral tests two times, approximately one year apart. The associations between both exposure measures and neurobehavioral performance were examined. Pesticide residues were detected in dust samples from both agricultural and non-agricultural homes, however, pesticides were detected more frequently and in higher concentrations in agricultural homes compared to non-agricultural homes. Although few differences were found between agricultural and non-agricultural children at both visits, deficits in learning from the first visit to the second visit, or less improvement, was found in agricultural children relative to non-agricultural children. These differences were significant for the Divided Attention and Purdue Pegboard tests. These findings are consistent with previous research showing deficits in motor function. A summary measure of organophosphate residues was not associated with neurobehavioral performance. Results from this study indicate that children in agricultural communities are at increased risk from pesticides as a result of a parent working in agricultural. Our findings suggest that organophosphate exposure may be associated with deficits in learning on neurobehavioral performance, particularly in tests of with motor function. In spite of regulatory phasing out of organophosphates in the U.S., we still see elevated levels and higher detection rates of several organophosphates in agricultural households than non-agricultural households, albeit lower levels than prior studies.

1. Introduction

Organophosphorus insecticides (OPs) are commonly used to control pests in agricultural settings, both in the United States and globally. OPs impact humans by interfering with the transmission of nerve impulses by blocking the normal breakdown of the neurotransmitter, acetylcholine, through cholinesterase inhibition. Through this mechanism of action, these insecticides have known neurotoxic properties, particularly in children [1,2]. Children are considered to be more vulnerable than adults to the toxic effects of OPs because of physiological differences such as immature metabolism and elimination systems [3].

Although use of these pesticides has been reduced and restricted in the United States, they are still applied to some agricultural crops [4]. Recent evidence suggests that low-level exposure to OPs during childhood and adolescence may have adverse consequences on neurologic development [5–9]. Also recent longitudinal birth cohort studies assessing prenatal exposures have shown deficits in cognition [10–12]. However, there are still questions about neurologic development deficits related to chronic exposures over time and the timing of exposure during critical windows of development.

Research has indicated that families living in agricultural communities have a greater risk from OPs due to chronic exposures than the general population [13–16], additionally children have greater exposure due to their behaviors such as crawling on the

* Corresponding author at: Department of Occupational and Environmental Health, University of Iowa, College of Public Health,145 N. Riverside Drive, Iowa City, Iowa 52242, United States. Fax: +1 319 384 4138.
E-mail addresses: diane-rohlman@uiowa.edu, dianerohlman@gmail.com (D.S. Rohlman).

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floor and more frequent hand-to-mouth activity [17]. Home carpet dust samples are commonly used to assess OP levels in the home. Prior studies have shown that pesticide levels in home dust are positively associated with the proximity of homes to pesticide-treated fields and with para-occupational pathways, agricultural workers inadvertently bringing pesticide residues into the home on their clothes, boots, skin and hair [13–15,18–20].

OPs have the potential to adversely affect the health and neurodevelopment of children living in agricultural communities where they are applied in the orchards and fields. Thus, the purpose of this study is to investigate associations between OP exposure and neurobehavioral performance in school-aged Latino children living in an orchard community. Furthermore, the possibility of potential learning deficits in children due to the impact of pesticide exposure was investigated. In the study, we compared two neurobehavioral evaluations performed approximately 12 months apart.

2. Methods

2.1. Study participants and design

This longitudinal study was conducted in an orchard community in the Pacific Northwest where OPs are commonly applied. Many families in this community work in the orchards or fruit packing houses. Children between the ages of 5 and 12 were recruited during a three-year period between 2008 and 2010. Recruitment occurred through word-of-mouth, at school, and at community events where a booth was set up with information explaining the study. Only one child per household was eligible to participate in the study. For each child, data were collected at two time points approximately one year apart. At both time points, children completed a neurobehavioral test battery, parents completed a series of questionnaires, and dust samples were collected from the homes. All test materials were administered to children and parents in their preferred language, either Spanish or English. The study was approved by the Institutional Review Board at Oregon Health and Science University.

2.2. OP exposures

Parent's occupation and OP residues in carpet dust samples were used to characterize exposure to pesticides in children. Children that had at least one parent currently working in agriculture were classified as agricultural and children that had neither parent working in agriculture during the previous five years were classified as non-agricultural.

2.2.1. Questionnaires

Parents completed a series of questionnaires to collect demographic information, occupational history, pesticide use at work and at home [14,21], In addition, the Home Observation for Measurement of the Environment (HOME) survey [22] was administered through interviews with the mother in the home, established HOME scores were calculated and higher HOME scores indicate a more enriched home environment; the School-age Child Behavior Checklist (CBCL) [23] was also completed, three established scores were generated from the CBCL (total behavior problems, internalizing problems and externalizing problems), higher scores indicate more behavioral and emotional problems. Children completed the Short Acculturation Scale for Hispanic Youth (SASH-Y) survey [24], established acculturation scores were

Table 1
Neurobehavioral test, function measured, and outcome examined.

Neurobehavioral tests and descriptions	Function	Outcome (measured unit)
1. Digit span	Memory & attention	Forward score (maximum digits)
Recall of number sequences		Reverse score (maximum digits)
2. Finger tapping	Response speed & coordination	Preferred and non-preferred hand (number of taps)
Tapping with preferred and non-preferred hand for 20 s		
3. Match-to-sample	Visual Memory	Average latency for correct choice (ms)
15 stimuli are shown for 3 s (10 × 10 matrix of blocks)		Number correct
Identify correct stimuli from 3 choices		
4. Symbol-digit	Processing Speed	Average latency of response for correct match (ms)
Digits are paired with symbols in matrix		
Match numbers to the symbols from the key		
5. Continuous performance	Attention	Percent correct hits (%)
Different shapes and targets shown rapidly for 4 min, subjects are instructed to press a key when a target is presented		D-prime, measures how well the participant discriminates non-targets from target
6. Divided attention	Divided attention	Control, tapping with no song
Tapping with preferred and non-preferred hand (control)		Preferred and non-preferred hand (number of taps)
Tapping while reciting the birthday song with preferred and non-preferred hand (distraction)		Distraction, reciting birthday song
		Preferred and non-preferred hand (number of taps)
		Preferred and non-preferred hand (number of times sang song)*
7. Object Memory*,a	Recall & recognition memory	Utilization
Show 16 objects and asked to recall name		Immediate recall of objects
		Recognition of target and non-target items
8. Purdue Pegboard*,b	Dexterity	Preferred hand (average number of pegs)
Place small pegs in holes during two 30 s trials with each hand and both hands		Non-preferred hand (average number of pegs)
		Both hands (average number of pegs)
9. Visual motor integration*,b	Hand-eye coordination	Figure copying score
Total score for correct line segments		
10. Name writing*,c	Visuomotor & fine-motor agility	Preferred hand, latency (s)
Time it takes to write name		Non-preferred hand, latency (s)

Abbreviations: ms, milliseconds; s, seconds.
[a] [8,32].
[b] Pediatric environmental neurobehavioral test battery [33].
[c] [34,35].
* Individually administered tests were selected from previous studies.