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Exposure to Environmental Hexachlorocyclohexane (HCH) and Dichlorodiphenyltrichloroethane (DDT) among Rural Children in North Eastern China [1]

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Objective To assess HCH and DDT exposure levels and associated risk factors among 262 children aged 6-10 years in a northeastern rural area of China between April and May of 2008. **Methods** Eight HCH and DDT metabolites in serum samples were monitored by gas chromatography. A questionnaire was administered to identify the sources of pesticides in children' serum samples. **Results** At least one pesticide metabolite was detected in 81.7% of the tested children. Higher amounts of pp'DDD were detected in 50% of them. Children's age and their father's occupation as farmers, together with not changing work clothes after work, were the main risk factors for HCH and DDT exposure among them. **Conclusion** Children living in rural areas are experiencing multiple sources of organochlorine pesticide exposure. These pesticides may have been retained in the environment for a long period of time.

Key words: HCH; DDT; Metabolites; Environment exposure; Children

INTRODUCTION

HCH and DDT are the main organochlorine pesticides (OCPs) that represent persistent organic pollutants (POPs). These pesticides can remain in plant and the environment for a long time[1], and can be further accumulated within food chains, thus increasing the risk to human health[2]. Environmental pollution of the ecological system has become a global issue[3]. Humans are affected primarily through breathing ambient air polluted by OCPs[4], eating animal food polluted by OCPs[5-6] or the contamination of farm workers' workplaces and households[7].

Children are susceptible to environment pollutants, including OCPs[5-6]. Children may be exposed to the OCPs through various pathways, e.g. direct contact by skin via contaminated clothes and milk by breast-feeding[5-6] or food products produced on polluted farmland[3]. Children may also be exposed to environmental pesticides if their parents are farmers who do farm work and directly contact with the soil containing OCPs residues, or if their houses are near agricultural lands[8].

There is around 55.1% of the population living on farmland in China[9]. HCH and DDT were the main pesticides used on the farmland 40 years ago[10]. Despite the ban of HCH and DDT use in China for 26 years, the residues are still found in the soils and hence have posed some risks for exposure to farmers[10]. A large proportion of farmers work manually rather than use automated machines. This working practice has not only made them at a risk for exposure to the pesticide residues in the soil directly, but also via their contaminated personal belongings, such as working suits and tools. Therefore, this also becomes a risk factor to their family members, especially to their children. So far, there is no report on these issues yet. In order to investigate the HCH and DDT exposure in children, this investigation was conducted in April of 2008 in which 262 children were recruited.

MATERIALS AND METHODS

This study was reviewed and approved by the ethical committee of the Harbin Medical University.

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All parents were well informed and consent forms were signed. The 262 children aged 6 - 10 years were randomly selected from 17 rural areas in Jiamusi city. These children had inhabited in the exposed areas since their birth.

Fast venous blood samples (10 mL) were taken and were left at room temperature for 15 min and then centrifuged at 500 × g for 20 min at 4 ℃. Sera were removed and stored at -70 ℃ for the metabolite analysis. Eight metabolites (α, β, γ, δ-HCH, pp'DDE, pp',op'-DDT, and pp'DDD) were analyzed by using gas chromatograph equipped with an electron capture detector (GC-17A, Shimazu, Japan). A capillary DB-5 column was used for all the analyses. This method was established based on the U.S. EPA method (U.S.EPA Method 508.1, 8081A, 5550, 3640A)[11-12] with some modifications. Briefly, 1 mL of serum was extracted by petroleum ether, dried by nitrogen gas flow and then dissolved in 1 mL of hexane for further analysis. Chromatographic conditions in this test were: injector temperature 250 ℃; electron capture detector temperature 300 ℃. The oven temperature was programmed as follows: 60 ℃ for 1.25 min, at 20 ℃/ min to 180 ℃ for 7 min, at 10 ℃/min to 230 ℃ with a final hold for 3 min; 2 μL of extracted solution was loaded onto the column.

A 45- minute questionnaire (form not shown) was administered by trained interviewers. The questionnaire captured the following information: children's sex, age, questions as whether their residential place was no more than 2 km away from agricultural fields and whether the crop stalks were used as cooking fuel, children's hygienic habits, children's dietary behaviors, parents' occupation, and their safe behavior after farm work, parents' educational background and the child's history of breastfeeding.

Data were analyzed using SPSS 13.0 for Windows Student Version. Bivariate analysis was used to analyze the associations between the number of detects and the indicated risk factors in order to identify potential risk factors. If the predicted risk factors were P<0.20, they were further assessed by using multivariate analysis to define the relationships between the single metabolite and the predicated risk factors. P<0.05 was considered to be statistically significant.

RESULTS

Of totally 262 children recruited, 91.2% of their mothers and 69.1% of their fathers did farm work, 60.7% lived in households with two farm workers and 36.3% resided in houses no more than 2 km away from agricultural fields. Crop stalks were the main burning fuel in about 82.1% of the families. On average, the children ate fish twice a week, ate meat 5 times a week, and drank milk 3 times a week. Of them, 71.7% washed their hands before having a meal. As to their parents who engaged in farm work, 53.8% did not take a shower immediately after work, and 53.1% changed their farm work suits only when they reached home; 52.7% stored their farm work clothes together with other clothes, and 33.6% washed their farm work clothes together with other clothes; and 34.4% of children's mothers and 25.6% of children's fathers had primary school education. Of the children, 84.7% had breastfeeding during their infancy.

At least one of the 8 metabolites of DDT and HCH were detected in 81.7% of the serum samples (Table1). Table 1 also shows the amount and different frequencies of metabolites detected in the samples. In this investigation, the absence of DDT and / or HCH serum metabolites was only found in 29.0% of the children. One or more than one metabolites of DDT/HCH were detected in 71.0% of the serum samples of the children. Among them, one, two, three, four, five, six, seven, and eight metabolites were detected in 13.0% (34), 13.7%(36), 11.1%(29), 4.6% (12), 7.3% (19), 5.0%(13), 6.1% (16), and 10.3% (27) of the serum samples, respectively.

TABLE 1

The Level of HCH/DDT Metabolitesin Serum Samples of Children Aged 6-10 Years in Rural Areas of JiaMuSi, China (n =262)

The Metabolite of HCH/DDT	LOD (ng/L)	Number of Detection (Detection rate,%)	Content in Sera (μg/L)	
			Mean ± SE	95th Percentile
α-HCH	0.0009	122 (46.56)	0.0093±0.0294	0.0341
β-HCH	0.0013	74 (28.24)	0.0044±0.0107	0.0156
γ-HCH	0.0010	96 (36.64)	0.0055±0.0136	0.0251
δ-HCH	0.0015	93 (35.50)	0.0063±0.0199	0.0180
pp'DDE	0.0010	84 (32.06)	0.0052±0.0136	0.0226
pp'DDT	0.0010	60 (22.90)	0.0039±0.0107	0.0194
op'DDT	0.0009	52 (19.85)	0.0048±0.0138	0.0289
pp'DDD	0.0013	131 (50.00)	0.0268±0.0524	0.1012

*Note.*LOD- limits of detection.

Five factors were found by the bivariate analysis to have a statistically significant association with the average number of HCH/DDT metabolites found in the children (Table 2). This showed a linkage between behavioral / environmental factors and the incidence of metabolite detection. Significant risk factors were those associated with parents' occupation as farmers and their behaviors of not taking a shower immediately after farm work. High incidence of metabolites was also found in children whose parents did not change their farm work clothes when they returned from their farm work. Children without breastfeeding history showed significantly higher numbers of HCH/DDT metabolites as compared to those with breastfeeding.

The metabolites present in these children's serum samples might provide three possible pathways of exposure: (1) Children's families were living in areas where OCPs had been used previously[10]; (2) Parents working as farmers and their lifestyle e.g. without taking a shower and changing contaminated farm work clothes after work helped to transport contaminated OCPs into their homes; (3) OCPs which remained in the soil or plants were drifting into the residential environment of children living via medium of air, soil, water, and food. These three potential pathways could be blocked by changing their parents' working habits if they appreciated and took appropriate actions.

The results of this study also showed that age exerted a strong influence on the pesticide metabolite levels. For instance, the younger children had both higher amounts and greater varieties of the metabolites of HCH/DDT present. Furthermore, HCH and DDT could remain in the environments in which the children live for long periods[6].

TABLE 2

Predictors with a Significant Relationship to the Number of Metabolites of HCH/DDT Detected in Serum Samples

Characteristic	Number of Detections (Mean ± SE)	Bivariate Analysis[a] (P)	Multivariate Analysis[a] (P)
Child's Age (years)		0.0014*	<0.0001**
6	3.90 ±3.11		
7	3.54 ±2.55		
8	2.57 ±2.93		
9	2.08 ±2.49		
10	2.30 ±2.54		
Father does Farm Work		0.0022*	0.0256**
Yes	3.17 ±2.90		
No	2.04 ±2.28		
Safe Behaviors after Farm Work			
Taking Shower Immediately after Farm Work		0.0997*	0.1034
Yes	2.51 ±2.69		
No	3.08 ±2.82		
Changing Farm Clothes before Arriving Home		<0.0001*	<0.0001**
Yes	2.17 ±2.27		
No	3.54 ±3.097		
Child's Breastfeeding History		0.0172*	0.1280
Yes	2.64 ±2.73		
No	3.77 ±2.83		

Note. [a]Other variables had been considered in the bivariate analysis. These variables included in the multivariate analysis were shown in Table 1**.** *$P<0.20$. **$P<0.05$.

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