

POEM model application feasibility with Diazinon poison using cholinesterase activity level measurement of farmers in the west regions of Iran

Sara Karimi Zeverdegani¹, Masoud Rismanchian¹, Samira Barakat^{1,*}, Mehdi Mirrezaei¹,

Akbar hassanzadeh²

¹ Department of Occupational Health Engineering, School of health, Isfahan University of medical sciences, Isfahan, Iran

² Department of Biostatistics and Epidemiology, School of health, Isfahan University of medical sciences, Isfahan, Iran

ABSTRACT

Introduction: The most common occupational exposure among farmers is exposure to pesticides. Organophosphate pesticides (OP) are widely used to control pests in agriculture. The main mechanism of Organophosphates (OPs) toxicity is irreversibly inhibiting of Butyl cholinesterase and acetyl cholinesterase. POEM model (Predictive Operator Exposure Model) was made to assess exposure to and absorption of the pesticides. The aim of this study was to estimate exposure to the organophosphates using POEM model and to compare its results with activity level of plasma cholinesterase (PChE) among farmers in the west regions of Iran.

Material and method: In this descriptive and analytical research, farmers were divided into two same groups who were exposed to diazinon. One group of them wore full personal protective equipment (PPEs) and the second group including farmers with daily routine work had no proposed personal protective equipment. Before and after spraying operation, a blood sample was collected from both groups of farmers, as well as from control group. Then, plasma cholinesterase activity was measured by DGKC (German Biochemical Society) and photometric device. Farmer's exposure to OPs was estimated with POEM model.

Results: The activity mean PChE enzyme in the groups with and without personal protective equipment was 11639.3 mg/l and 8516.3 mg/l, respectively. The predicted mean total absorbed dose and predicted total exposure to the toxic substance in group with PPEs was 9.1 mg/day and 0.15 mg/kgbw/day, respectively and in the group with PPEs were 0.5 mg/day and 0.009 mg/kgbw/day, respectively. Using of the POEM model, dermal exposure average, percentage of dermal absorption, absorbed dose at the time of preparing the poison solution and spraying was significantly higher in the no PPE group as compared to the PPE group ($P < 0.001$).

Conclusion: This study showed that the use of personal protective equipment prevents from the effects appearing of pesticides by reducing the activity of PChE. With the increasing in PChE activity, the values of POEM model parameters decreases such as the absorbed dose of the skin and the inhalation of the toxin. Therefore, the POEM model can be used to check the exposure of people with pesticides. Finally, this study suggests that the POEM model can be considered as a screening tool to identify individuals at exposure of pesticides to the next steps for biological monitoring, diagnosis and treatment.

Keywords:

Cholinesterase enzyme, Farmers, Organophosphate pesticide, Personal protective equipment, POEM model

*Corresponding Author: Samira Barakat,

Email Address: samirabarakat.ohs@gmail.com

1. Introduction

Research shows that exposure in the agricultural job settings are the most common cause of contact to pesticides (1). The US Environmental Protection Agency (USEPA) has defined pesticides as any substances or mixtures considered for preventing, destroying, removing or reducing any pests (2). OP poisoning is a major problem worldwide, especially in developing countries, with millions of cases and hundreds of thousands deaths occurring each year (3). The OP compounds are diverse classes of pesticides with the most well-known applications as insecticides and, to a lesser extent, as herbicides in agriculture. Due to the fast rate of degradation of OPs in the environment, they have been a suitable replacement for organochlorines. In 2007, 15 million kg of OP pesticides, representing 36% of all insecticides were used in the United States (4). Dermal exposure is one of the issues that need to be addressed in the assessment of exposure for regulatory risk assessment of chemicals. In risk assessment of agricultural pesticides, the skin has been recognized to be a major route of exposure for many years now (5). The aim of this study was to estimate exposure to the organophosphates using POEM model and to compare its results with activity level of plasma cholinesterase (PChE) among farmers in the west regions of Iran.

2. Material and Methods

This cross-sectional and experimental research was done to validation of UK POEM model with using the level of cholinesterase of farmers exposed to OPs. This research was conducted in several stages among 34 male farmers, who spraying and exposing to the OPs pesticides, in the west regions in Iran in 2016. In the first stage a questionnaire was used among the selected farmers divided into two equal groups about last exposure time (between 3 to 6 months), range of age (30 to 35 years), the average hours of spraying (3 hours per week), agricultural history, history of smoking and poisoning. In the second stage one group wear full protective clothing including shirts,

pants and gloves and masks with filtered) model, BLUEEGLE) of the N and P Series which were appropriate for the agricultural spraying works. The second group included farmers with their daily routine work without the use of proposed personal protective clothing. The group of healthy people with similar conditions, who were not exposed to the considered pesticides, was selected as the control group. In the third stage, before and after spraying operation, blood sample was collected from both groups of the farmers as well as from the control group then, PChE activity were measured by DGKC and photometric device (model, TS Technology). In the fourth stage farmers' exposure to OPs was estimated with POEM model. Statistical analysis was done using SPSS20, Chi-square test, Paired t-test and Pearson correlation.

3. Results and Discussion

Demographic data of the studied people in three groups were shown in table 1. Chi-square test with likelihood ratio showed that smoking frequency distribution in the considered farmers had no significant differences between the three groups ($P=0.42$). Frequency distribution and percentage of people with regards to the history of toxicity were exactly similar for the two groups of farmers using or not using the safety suits. Frequency distribution of the studied people with regards to smoking and in history of toxicity the three groups are shown in table 2. One-way variance analysis test showed that average level of PChE had significant differences in the three groups before spraying ($P=0.04$). The pursuant LSD test showed that before spraying, Average level of PChE in the control group was significantly more than the group without the safety suits ($P=0.04$), and with the safety suits ($P=0.02$). However, significant difference was observed between the two groups with and without the safety suits ($P=0.80$). Ebrahimzadeh showed in his study on rice farmers significant differences in plasma AChE between exposed and control group ($P<0.05$) (6). Hector study on 213 farmers and 78 in a control group, showed that PChE

activity levels in agriculture are significantly lower than the control group (7). In a similar research conducted in Ethiopia by Mekonnen & Ejigu among 82 farmers and 47 individuals, as a control group, showed that PChE activity was lower in among the farmers (8). Independent t-test showed that mean PChE enzyme in groups with personal protective equipment was significantly higher than group without this clothing ($p > 0.001$). Mean of dermal exposure, dermal percent absorbed, absorbed dose during spraying and solution preparation in group without PPE were significantly higher than those with use of PPE ($p < 0.001$) and predicted total absorbed dose and predicted total exposure to toxic substance in group without PPE significantly higher than group with PPE ($p < 0.001$). Results showed that mean of inhalation exposure, concentration of toxicant in spray inhalation absorbed dose during spraying and solution preparation in two groups was same (table 3). The average amount of dermal exposure to the pesticide, dermal Percent absorption and dermal absorbed dose during spraying and solution preparation in the farmers without PPE were significantly higher than in the group with PPE ($p < 0.001$). Predicted total absorbed dose and predicted total exposure to toxic substance in the group without PPE was significantly higher than in the group with PPE ($p < 0.001$). The average inhalation exposure to pesticide, toxic concentrations in the spray, inhalation absorbed toxic substance during reparation of the solution was identical in the two groups since in the model parameters there was no part as the use of inhalation

protection equipment ,therefore the parameters of the two groups were similar. As can be seen in Table 3 dermal exposure in both groups (with and without PPE) during spraying is higher than during solution preparation. Paired t-test showed that the amount of dermal exposure to toxic substance in both two groups during pesticides spraying was significantly greater than during solution preparing ($p < 0.001$). Dermal percent absorption and dermal absorbed dose in the groups without PPE during spraying significantly higher than during solution preparation ($p < 0.001$, $p = 0.001$ respectively) but no significant different was seen between two groups with PPE. Different parameters in farmers before and during spraying are shown in table 4.

4. Conclusions

It is concluded that with the increase in the PChE activity, value of parameters in POEM model were decreased and the reverse relationship was also significant. In other words, the use of personal protective clothing prevents the effects of the pesticides on the reduction of PChE activity. Using predictive models of the chemical materials exposure would help to reduce laboratory methods costs in measuring exposures and absorbed chemical doses. Therefore, further researches would be necessary in the use of predictive models to achieve the desired results and saving time.

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Table 1. Average age, weight, height and BMI of the considered people in three groups

Parameters	Group without the safety suits		Group with the safety suits		Control group		P-value
	mean	SD	mean	SD	mean	SD	
Age(yr)	38.1	9.1	35.2	11.3	34.8	12.1	0.63
Weight(kg)	71.6	9.4	73	8.2	77.3	12.8	0.25
Height(cm)	174.1	6.8	177.3	6.3	177.4	6.6	0.25
BMI	13.7	3.1	23.2	1.9	24.5	3.3	0.39

Table 2. Frequency distribution of the studied people with regards to smoking and in history of toxicity the three groups

Parameters		Group without the PPE		Group with the PPE		Control group		P-Value
		N	%	N	%	N	%	
Smoking	Yes	5	29.4	4	23.5	2	11.8	0.42
	No	12	70.6	13	76.5	15	88.2	
Toxicity	Yes	12	70.6	12	70.6	-	-	
	No	5	29.4	5	29.4	-	-	

Table 3. Different parameters in two groups of farmers in spraying and solution preparation

Time	Parameters	Group without PPE		Group with PPE		P-value
		Mean	SD	Mean	SD	
After spraying	PChE	8516.3	1523.8	11639.3	1470.4	<0.001
During spraying	Concentration of toxicant or spray	0.57	0	0.57	0	1
During solution preparation	Dermal exposure	0.85	0	0.04	0	<0.001
During spraying	Dermal exposure	60.6	0	42.6	0	<0.001
During solution preparation	Dermal Percent absorbed	3.7	0	0	0	<0.001
During spraying	Dermal Percent absorbed	25.9	0	1.8	0	<0.001
During solution preparation	Dermal absorbed dose	0.05	0	0	0	<0.001
During spraying	Dermal absorbed dose	8.9	0	0.45	0	<0.001
During spraying	Inhalation exposure	0.05	0	0.05	0	1
During spraying	Inhalation exposure	100	0	100	0	1
During spraying	inhalation absorbed dose	0.08	0	0.08	0	1
During spraying and solution preparation	Predicted total absorbed dose	9.1	0	0.5	0	<0.001
During spraying and solution preparation	Predicted total exposure to toxic substance	0.15	0	0.009	0	<0.001

Table 4. Different parameters in farmers before and during spraying

Time	Parameters	Group without PPE		Group with PPE	
		Mean	SD	Mean	SD
During solution preparation	Dermal exposure	0.85	0	0.04	0
During spraying	Dermal exposure	60.6	0	42.6	0
	P-value	<0.001		<0.001	
During solution preparation	Dermal Percent absorbed	3.7	0	0	0
During spraying	Dermal Percent absorbed	25.9	0	1.8	0
	P-value	<0.001		0.55	
During solution preparation	Dermal absorbed dose	0.05	0	0	0
During spraying	Dermal absorbed dose	8.9	0	0.45	0
	P-value	0.001		0.67	

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